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# THE PORT ARTHUR-ORANGE BRIDGE, TEXAS, U.S.A.

(*Concluded from page* 66.)

WORK on the erection of the steelwork of the bridge was begun on the approach spans and was carried forward, on both sides of the river, to the main tower spans, the last main erection operation being the placing of the suspended span at the river crossing. One reason for the adoption of this procedure was that the contract called for the employment of local labour and as men used to working at great heights were not available, it was considered that operating first on the lower spans of the approaches, the men employed would gradually gain the confidence and steadiness necessary for working at the maximum height of some 230 ft. above the surface of the river. As already described, and as shown in Fig. 19, Plate VI, *ante*, the approaches each begin with 12 reinforced-concrete spans, followed by fifteen 60-ft. joist spans. A photograph of this part of one of the approaches is reproduced in Fig. 44, on Plate IX. The spans were erected by means of the floating crane on the construction canal. When the first two had been erected, the same crane was then used for assembling on them the travelling crane which is shown in Fig. 44. The purpose of this was the erection of the joists and cross members of the remaining spans. Actually, it was found possible to erect the first eight spans by means of the floating crane, but after that the height became too great and the traveller had to be used. The method of working was for the floating crane to move ahead of the traveller and to erect the tower bents. It also placed the joists and cross girders of the deck in a position within reach of the traveller, which then picked them up and put them in place. The steel was brought up the river from the fabricating plant in large barges, and then unloaded into smaller barges which travelled up the construction canal. The traveller, which was operated by a petrol engine, had an 88-ft. jib.

As will be clear, no falsework was required for the erection of these joist spans, but at the inner end of the last one, a temporary H-frame was necessary to carry the end of the span from the first tower of the lattice spans until the girders for the first of these spans were in place. The lattice spans being considerably deeper than the joist spans, this tower, as shown in Fig. 44, is considerably shorter than the one immediately before it. For the erection of the 170-ft. and 150-ft. lattice spans falsework was necessary. This is also shown in Fig. 44. Temporary support of this kind was used at eleven places on each side of the river. The procedure used was to erect the bridge towers ahead of the erection of the spans, which were fabricated in two sections, each about 75 ft. long, for the 150 ft. spans and in three shorter sections for the 170-ft. spans. In general, falsework was used for the alternate spans, those between being erected by cantilevering out. The 25-ton travelling crane, which was carried by one finished span and used to erect the next, travelled on a temporary 19-ft. gauge track laid on the span cross girders, as shown in Fig. 57, on page 130. As, in view of the weights to be lifted, this track was comparatively narrow, the floating crane in the canal placed the various bridge sections in such a position that the traveller could pick them up in the line of the work, without having to slew to a side position. Furthermore, the traveller was secured to the bridge structure at the front and rear and ties were run from the top of its A frame to an anchorage at the rear. The socket of the 30-ft. centre post of this crane was also designed to resist any lifting tendency when the long jib was handling heavy loads.

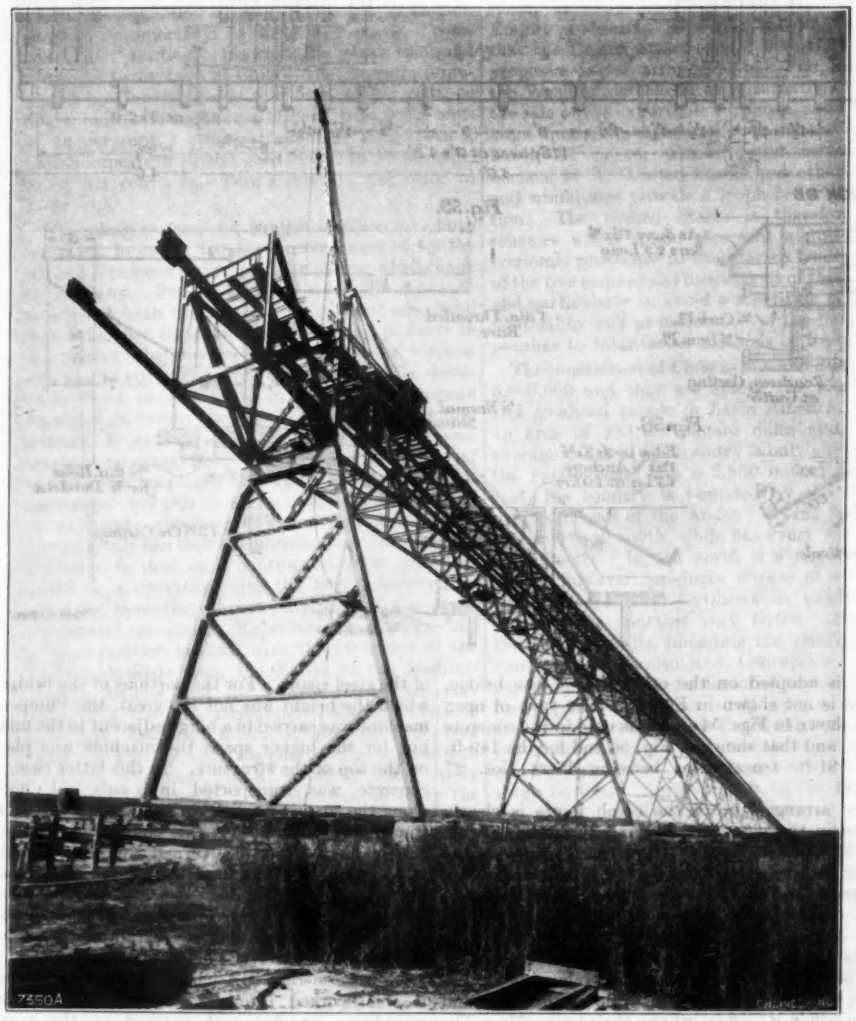



FIG. 43. START OF ERECTION OF CANTILEVER ARM.

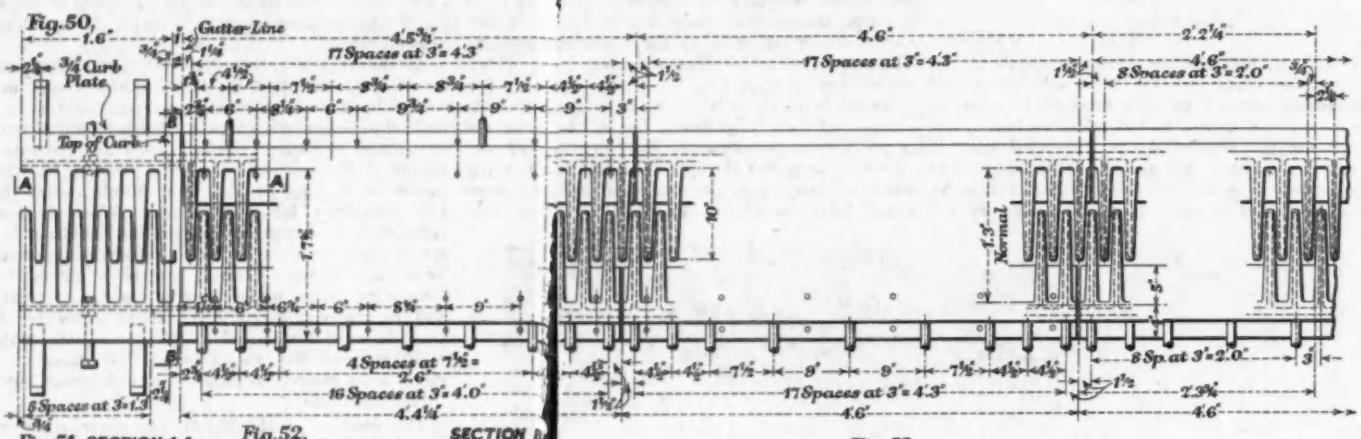
As shown in Fig. 19, Plate VI, *ante*, there are 300-ft. and 299-ft. 9-in. lattice-girder spans on each side of the main cantilever spans, and as explained in the previous article, these are built as two continuous two-span groups, carried by triangular towers at the centres. For their erection, it was necessary to support the first, 300-ft., span on two temporary falsework towers. When it was completed it served to anchor the 299-ft. 9-in. span which was built out as a cantilever supported by a single falsework tower. As the height of the temporary towers under these spans was so great, and it was considered desirable to allow for a possible wind loading of 25 lb. per square foot, additional stability was provided by fitting outrigger arms secured to piles arranged to resist both thrust and uplift.

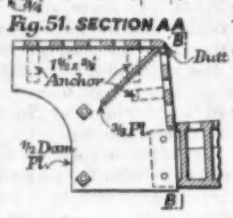
The erection of the 374-ft. cantilever arms on each side of the river crossing, and the large triangular towers supporting them, was the most difficult part of the work, as the design provided for a rigid connection at the tops of the towers over Pier No. 37 on the south side of the river and Pier No. 40 on the north side. These piers are indicated in Fig. 19, Plate VI, *ante*. Part of the arm was erected as a cantilever from the end of the 600-ft. continuous girder made up of the two spans which have just been referred to. The beginning of this operation is illustrated in Fig. 43, on this page. The traveller was moved forward on the cantilever sufficiently far to enable the steelwork of the span to be erected up to a temporary falsework tower which was located under the third panel point. This position will be clear from the view of the completed span given in Fig. 45, on Plate IX. The steelwork was lashed to the falsework tower in order to resist longitudinal forces during the erection of the span.

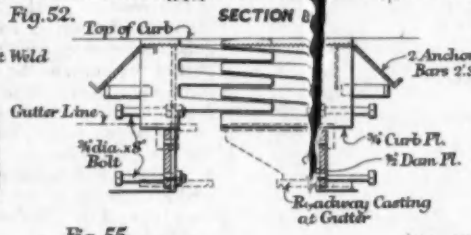
A second falsework tower was built under the seventh panel point. This was the highest tower which was used in the work. The tower legs reached a height of 150 ft. and each consisted of two 18-in., 42·7-lb. channels to a height of 86 ft., above this 12-in., 65-lb. joists being used. Structural-steel brackets extended outwards from the tower in the direction of the approaching traveller. This was used to enable the traveller crane to pick up erection loads one panel point away from the tower. Jacking equipment and shims were introduced between the top of the tower and the steelwork of the span, so that when the work of erection was completed the jack could be operated to release the shims and allow the tower to be dismantled. With the completion of the second falsework tower, it was possible for the traveller to move forward far enough to erect the upper sections of the large triangular tower over Pier No. 38. The lower part of this tower was erected from the floating crane. A similar arrangement was used in connection with the tower over Pier No. 39 on the other side of the river.

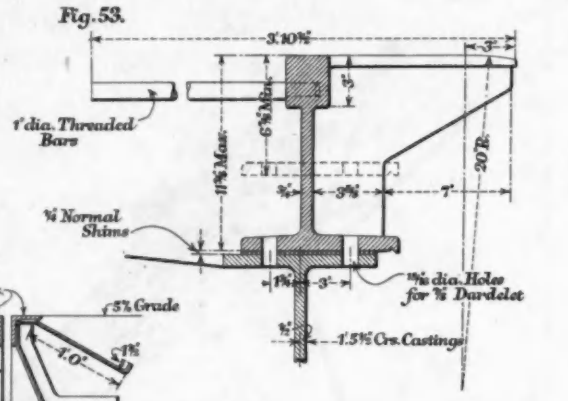
The traveller, on each side of the river, was then moved forward until it was over the large triangular tower and the erection of the main span across the river proceeded by cantilevering out. An early stage of this work is shown in Fig. 45. When the point of connection between the cantilever arm and the centre suspended span was reached, 300 ton hydraulic jacks were installed at the connection between the two parts, in both the upper and lower chords. A view of this stage of the work, showing the centre suspended span partly constructed, is given in Fig. 46, on Plate IX. The jacks in the upper chord were set at slotted pin connections, which were provided to allow relative movement of the spliced members in the finished structure. The lower-chord jacks were set at the panel point where the suspended span is supported. The jacks facilitated either shortening or lengthening of the chords during the closing operation. The cantilever portions of the span were erected slightly above their normal positions in order to enable the top chord to be closed by slacking-off the jacks and lowering the cantilever, thus permitting the closure pin to be driven. The connection of the top chord is

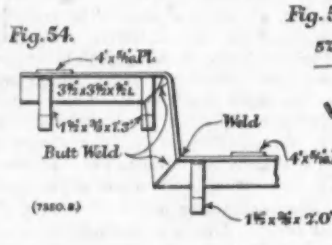
# THE PORT ARTHUR-ORANGE BRIDGE, TEXAS, U.S.A.

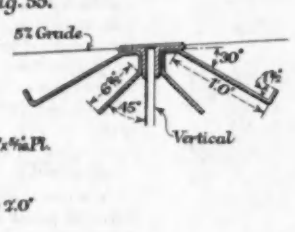


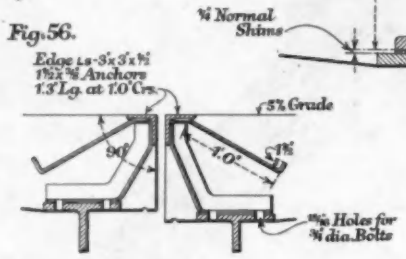




illustrated in Fig. 47, Plate IX. The closure of the bottom chord was effected by operating the jacks so as to lift the span slightly. A jacking pressure of about 250 tons per truss was required. The closing of the lower chord is shown in Fig. 48, Plate IX.

When the closing operation had been completed, the load on the lower jacks was reduced to 150 tons. The top jacks were then entirely released, with the result that there was a horizontal movement of the ends of the cantilever arms away from the towers and the bottom-chord jacks were also released, the centre span automatically taking up its suspended position. The various bridge members were brought to the site in barges on the river, and hoisted by the travelling cranes, as shown in Fig. 48. The only difficulty which arose with the arrangement was that the barges had frequently to be moved because they were interfering with the river navigation. There was also some loss of time in windy weather when the work could not proceed. The structural calculations were based on the assumption that the chords would be closed at a temperature of 70 deg. F. They proved closely accurate, the departure from the exact position being about 1 in. This had to be taken up by the jacks. A view of the completed river crossing is given in Fig. 49, on Plate IX.

The bridge is provided with a steel handrail carried from the cross-joints, as shown in Fig. 57, page 130. The roadway consists of a reinforced-concrete slab laid on the joists and provided with a number of expansion joints. The reinforcement consists of rolled lattice-web I-section members made by the Jones and Laughlin Steel Corporation, and known as Jaltrusses. They are laid longitudinally along the bridge, as shown in Fig. 58, on page 130, which is a view taken during the construction of the roadway slab. Two types of expansion joint are used and are illustrated in Figs. 50 to 56, above. The comb joint, shown in Figs. 50 to 53, is fitted at Pier No. 31, and in the spans between Piers Nos. 13 and 14, Piers Nos. 19 and 20, and Piers Nos. 25 and 26. As will be seen from Fig. 19, these are all 60-ft. deck-girder spans. A similar arrangement is adopted on the other half of the bridge, which is not shown in Fig. 19. The type of open joint shown in Figs. 54 and 55 is used in the concrete spans, and that shown in Fig. 56 and for the 149-ft. and 191-ft. truss spans between Piers Nos. 27 and 35.

The arrangement of the comb joints is clearly shown in the plan, Fig. 50, and the cross section, Fig. 53. The combs are steel castings, ground on the upper surface and galvanised. Their flat bases are secured to the cross joists of the bridge by means of $\frac{7}{8}$-in. diameter Dardelet rivet bolts, as shown in Fig. 53, and threaded bars extending from the heads secure them to the floor reinforcement. As will be seen, the comb arms are adequately strong, being $\frac{3}{4}$ in. thick and $1\frac{7}{8}$ in. wide at the roots and being stiffened by $\frac{1}{2}$-in. ribs on their lower side. The arrangement of the combs at the curb is illustrated on the left of Fig. 50, and in Figs. 51 and 52. The depth of the comb castings varies across the width of the bridge in order to suit the roadway camber; this is indicated in Fig. 53. The construction of the open expansion joints is clearly shown in Figs. 54 to 56, which require little comment. In the case of the joints in the concrete spans, shown in Figs. 54 and 55, the $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in. angles which form the upper edges of the joint are riveted to flats which are embedded in the concrete road slab. The angles are curved to the crown of the road and extend for the full width. If more than one length is necessary, they are welded together. The angles at each curb are connected by a 4-in. by $\frac{3}{8}$-in. top plate, as shown in Fig. 54, which illustrates the arrangement at the curb. The angles are galvanised. In the case of the joints in the steel spans, the reinforcement, in addition to the flats, consists of $2\frac{1}{2}$ in. by 2 in. by $\frac{3}{8}$ in. angles bent to the form shown and bolted to the cross joists of the bridge. They are secured by $\frac{3}{4}$-in. diameter bolts, shims being used if necessary under the bent angles in order to secure an even bearing.

The Pumpcrete method of distribution was adopted for running the concrete for the floor slabs of the steel spans. For the portions of the bridge of which the height was not too great, the Pumpcrete machine was carried in a barge adjacent to the mixer, but for the higher spans the machine was placed on the top of the structure. In this latter case, the concrete was transported in 1-cub. yd. lorries along the roadway to within about 150 yards of the Pumpcrete machine. At this point the lorries were run on to a turntable, turned round and backed up a ramp of approximately 22 per cent. grade. From the top of the slope they dumped their loads into the hopper of the Pumpcrete machine, which delivered the concrete over a maximum distance of 600 ft. and to a vertical height of about 40 ft.

As the concrete was delivered to the deck forms, it was worked into place with two pneumatic vibrators, screeded and finished to the correct grade and camber. It was then covered with burlap and kept wet for 24 hours, afterwards being covered with sand and kept moist for seven days. During this curing stage, it was protected from the weather by a travelling shed which was carried on the bridge handrails, as shown in Fig. 58, the shed being moved forward as required. The concrete work also included the construction of the twelve 31-ft. 9-in. reinforced-concrete spans at the outer ends of each of the approaches. In all, a total of 6,500 cub. yd. of concrete were placed.

The bridge was built by the Highway Department of the State of Texas, under the supervision of Mr. G. G. Wickline, Mr. P. V. Pennypacker acting as construction engineer. The contractors for the sub-structure were the Union Bridge and Construction Company, of Kansas City, Missouri, the Austin Bridge Company, of Dallas, Texas, acting as sub-contractors for all approach piers with pile foundations. The contractors for the superstructure were the Taylor, Fichter Steel Construction Company, of New York. The contract of this company covered the erection of 9,285 tons of structural steel and also the building of the concrete girder spans at the outer ends of the approaches.

# MARKETS IN CHILE AND PERU.

THE development of Chile and Peru, as in most other South American countries, has been due primarily to the pioneer work of British capitalists and engineers; the total amount of British capital invested in Chile is estimated at some 86,000,000*l.* sterling, and in Peru about 30,000,000*l.* However, as pointed out in the article which appeared in ENGINEERING of May 17, dealing generally with "The Markets in Latin America," for some years before the present war Germany was able to penetrate deeply into the import markets of Chile and Peru, among other South American countries, through the operation of the *Aski* mark in "compensation" trading. Between the years 1932 and 1938, the percentage of Chile's total imports represented by German goods rose from 15 per cent. to 26 per cent., and in the case of Peru, from 9 per cent. to 16 per cent.; whereas, over the same period, Chile's imports of British goods fell from 13 per cent. to 9½ per cent., and Peru's from 17 per cent. to 8 per cent.

The whole outlook for British imports into both republics, however, has been quite changed by the present European war and the British naval blockade of Germany. Fortunately, the outbreak of hostilities found both Chile and Peru without any large frozen balance in *Aski* marks, and the position in this respect is believed to have been adjusted without any loss to either country. Moreover, as the dominant trend of the trade of all Latin American republics in recent months has been an all-round setback to exports—due to the loss of European markets resulting from the German occupation of various countries—one important result has been a movement towards a great extension of clearing or payments agreements with Great Britain. A second result has been suggestions of a United States initiative to deal on a continental scale, and probably in co-operation with the British authorities, with the mounting export surpluses of the Latin American countries. Expressed concisely, the present position is that, with the extension of the British blockade from the Baltic to the Mediterranean, Britain and the United States are now practically the only remaining important markets for Latin American products, and, on the other hand, are also the chief suppliers of Latin American imports. Therefore, both countries are vitally concerned in assisting Latin America to carry the present surplus of production, especially so as to counter any promise or later attempt by Germany to make capital out of Latin America's difficulties by reimposing a widespread barter system such as that which, for some years before the war, proved so inimical to British and American import trade with Latin America.

Dealing first with Britain's new clearing agreements, the official Treasury announcement on July 18 regarding the virtual abolition of "free" sterling also intimated that, in addition to the recent agreements in official sterling with both Argentina and Brazil, the conclusion of clearing agreements with the Latin-American group as a whole might be expected shortly. Undoubtedly, agreements with both Chile and Peru are pending, particularly as the trade balance of both countries has been consistently in their favour against Britain. Payments or clearing agreements, which are desired by our authorities as part of the policy of restricting the influence of the free rate for sterling, are particularly appropriate to foster trade under present conditions. In effect, the extent to which Britain can replace Germany, Italy, and the invaded territories as a buyer of South American products now determines the purchasing power of the South American countries for British goods. This being the case, trade can best be promoted on a compensation basis. In so far as a payments agreement ensures reciprocal trade between the participating countries, it is an extension of compensation trade, but with the important distinction that the currency employed is not artificially depreciated, as was the case with *Aski* marks used by Germany, before the present war, in conjunction with other means of export subsidising.

With regard to Washington's proposed policy of dealing with Latin-American export surpluses, the outstanding problem being discussed at the present Pan-American Conference in Havana is the economic security of the Americas, which is, of course, indissolubly bound up with the maintenance of political integrity in view of the menace from the totalitarian powers. Among the vast surpluses now piled up in Latin America may be included cotton in Peru, while Chile has been left with more than one-third of her copper on her hands owing to the collapse of France. While Britain is anxious and willing to assist Latin America as far as possible, our capacity to import raw products from that sphere is limited by considerations of shipping space, exchange resources, and commitments to Empire producers. Therefore, it is right and proper that the United States should take the lead in the proposed cartel arrangements. The intention of the Washington scheme is apparently to centralise the sale of the exportable surpluses, so as to prevent large quantities being thrown on the market at knock-out prices, which would certainly be a menace to the United States and other producers, and would also provide a loophole for Axis infiltration. The United States is therefore fostering schemes which would represent a united front of economic resistance to totalitarian trade, in defence of the free commercial institutions of the New World, and particularly to avoid a repetition of the evils—political as well as economic—of the barter system, peculiar to totalitarian methods of trade.

The population of Chile is estimated at just under 5,000,000 and they are among the most energetic and go-ahead people in Latin America. Chile has an area of 285,100 square miles and, while the average width of the country is only about 80 miles, the Pacific coast line is 2,800 miles long. On the east, the country is bounded by the tremendous mountain wall of the Andes. Owing to the length from north to south, Chile has every variety of soil and climate. In the north is a region of desert, which, however, produces nitrate of soda, one of the most valuable fertilisers in existence. The central zone contains very fertile valleys and is the heart of Chile, including the principal cities of Santiago, Valparaiso and Concepción, which are modern and imposing; factories have sprung up in many places. Farther south comes the farming area, from Concepción to Puerto Montt, and farther south still, the cold and stormy region containing much virgin forest and given over principally to sheep farming. Agriculture is an important industry, as also are fishing and forestry, but the chief wealth is derived from mineral deposits, especially copper and nitrate of soda. The effect of conditions in the international markets on the two latter products is demonstrated in Table I, herewith, which shows Chile's foreign trade from 1928 onward.

TABLE I.—*Chile: Imports and Exports.*

| Year. | Values in Pesos (of 6d. Gold). | | |
|---|---|---|---|
| | Imports. | Exports. | Trade Balance. |
| 1928 .. | 1,200,000,000 | 1,964,300,000 | + 764,300,000 |
| 1929 .. | 1,601,200,000 | 2,282,800,000 | + 681,600,000 |
| 1930 .. | 1,400,124,700 | 1,328,123,000 | − 72,001,700 |
| 1932 .. | 213,785,800 | 290,494,000 | + 76,708,200 |
| 1936 .. | 346,733,300 | 562,269,400 | + 215,536,100 |
| 1937 .. | 428,866,400 | 947,588,800 | + 518,722,400 |
| 1938 .. | 498,956,900 | 682,857,600 | + 183,900,700 |
| 1939 .. | 410,832,800 | 671,364,500 | + 260,531,700 |

The published figures of foreign trade record, with the exception of 1930, a favourable balance of trade for many years past. In fact, however, it is doubtful if the real balance of trade is favourable to Chile, particularly as the two principal exports—copper and nitrates—are subject to certain regulations which preclude the whole of the corresponding exchange proceeds becoming available to pay for imports. The figures given in Table I, moreover, reveal fully the slump in Chile's export trade following the crisis of 1932, and the adverse effect of the corresponding lowering of purchasing power upon the volume of imports. The sharp rise in exports in 1937 was due to the boom in copper and other metals owing to European rearmament, but it will be seen that total exports for the year 1939 were about one-third of those in 1928.

Nitrate of soda was formerly Chile's main source of wealth, but, after the Great War of 1914-18, did not continue to be. The nitrate deposits no longer command a monopoly of the market for fixed nitrogen, synthetic processes of manufacture in Europe and the United States now supplying a large part of the demand. In 1913, Chile supplied 90 per cent. of the total volume of nitrogenous fertilisers to the whole world, but this proportion has now shrunk to under 10 per cent. The industry is faced with quota arrangements established by various consuming countries to foster their own synthetic-nitrogen industries. Therefore, Chilean nitrate is not in such demand during the present war as was the case in 1914-18, although there has lately been a better tendency, shipments in the first four months of 1940 having reached 737,480 tons against 630,490 tons in the like period of 1939, and the value having risen to 66,373,500 pesos (of 6*d.* gold) against 56,744,200 pesos.

TABLE II.—*Principal Exports from Chile.*

| Exports. | Volume in Metric Tons. | | Value in Thousands of Pesos (of 6d. Gold). | |
|---|---|---|---|---|
| | 1939. | 1938. | 1939. | 1938. |
| Copper bars .. | 312,300 | 349,300 | 331,640 | 328,818 |
| Nitrate of soda | 1,584,500 | 1,572,800 | 142,600 | 141,557 |
| Iodine .. .. | 400 | 598 | 8,400 | 11,177 |
| Cereals, vegetables, fruit, etc. | — | — | 52,522 | 66,756 |
| Wool .. .. | 11,627 | 9,746 | 27,740 | 25,346 |
| Iron ore .. | 1,592,000 | 1,553,900 | 13,660 | 13,478 |
| Gold bars .. | 2,555 kg. | 847 kg. | 10,909 | 4,209 |
| Other metallic minerals, concentrates and precipitates .. | — | — | 37,395 | 36,367 |
| Lentils .. .. | 21,850 | 44,982 | 9,843 | 17,874 |
| Beans .. .. | 22,978 | 38,675 | 9,121 | 9,880 |

Copper has now replaced nitrate as Chile's chief export, and, as will be seen from Table II, above, the annual shipments of this metal now represent by value about 50 per cent. of Chile's exports; therefore, much depends upon international war-time demand for this metal. Chile also produces iron, gold, silver, manganese and other metals, as well as petroleum and a variety of minerals, including notably sulphur. Chile is one of the few South American sources of coal, and, although this is of the soft variety, it is of good quality and has a high content of volatiles. It is thought that sooner or later it will be turned to good account by a low-temperature distillation process.

TABLE III.—*Imports of Engineering Products into Chile: Value in Thousands of Pesos (of 6d. Gold).*

| | 1936. | 1939. |
|---|---|---|
| (*a*) *Iron, Steel and Other Metals and Manufactures*— | | |
| Iron and steel unelaborated .. | 19,231 | 21,678 |
| Other metals (in sheets) .. .. | 933 | 1,244 |
| Metallic materials for various purposes .. .. .. | 5,330 | 8,328 |
| Iron and steel manufactures .. | 15,702 | 16,847 |
| Other metal manufactures .. | 3,215 | 3,684 |
| (*b*) *Machinery, Tools, Electrical Material, etc.*— | | |
| Mining machinery .. .. | 4,007 | 3,655 |
| Agricultural machinery .. .. | 2,010 | 3,383 |
| Unspecified machinery .. .. | 29,343 | 27,945 |
| Motors, boilers, and parts .. | 5,786 | 7,869 |
| Electrical machinery, apparatus and material .. .. .. | 11,610 | 13,517 |
| (*c*) *Transport Material*— | | |
| Machinery, equipment and material for railways and tramways .. .. .. | 11,125 | 4,147 |
| Ships and material for navigation | 169 | 1,519 |
| Unspecified vehicles and parts .. | 15,778 | 35,120 |

Lately, however, there has been a severe shortage of coal in Chile, largely due to the disaster at the Schwager colliery, as well as to labour difficulties, so that coal is now being imported from Britain. The present Government is of a moderate Left character, with a tendency towards the nationalisation of natural resources, as exemplified by a recent proposal to establish State control of ship-building and the metallurgical industries and to reserve iron-ore deposits for the State. On the other hand, the Government has made it clear that it will not allow labour controversies to interfere

with production, and important schemes of public works are under consideration, including large-scale plans for road building. Following the earthquake in January, 1939, a Corporation for Reconstruction and Development was formed, whose estimated expenditure involves some 2,500,000,000 pesos.

Industry generally is free from State interference, although national industries are fostered by a protective policy. The industrial development of Chile has been enormous over the past ten years, and is receiving additional stimulus owing to the difficulty of obtaining imported goods during the present hostilities. The general index of industrial production in January, 1940, was 168 (basis 1927-29 = 100). There are nearly 6,000 manufacturing establishments in Chile, employing about 300,000 people, and Chilean manufacturers concern themselves chiefly with the production of low-priced goods of every description, for which there is a brisk inquiry. Progress is due, to a great extent, to the readily available supply of motive power for machinery, especially electrical energy, and no fewer than 3,000 factories use electricity in the region of which Santiago and Valparaiso are the chief centres. The electrical services of the country are under the direct control of a State Department, there being some 200 companies distributed among 238 cities; and over 422 million units are generated yearly. The development of air services has resulted in the establishment of aircraft factories; the cement output is some 300,000 tons annually; the chemical industry turns out raw materials as well as finished goods, and railway trucks are now built on a large scale for the national railways. Iron and steel products are also produced locally, and there is a national iron-smelting establishment at Valdivia.

Imports into Chile of iron, steel and other metals and manufactures in 1939 were worth 51,781,000 pesos (of 6*d*. gold), compared with 44,411,000 pesos in 1936; those of machinery, tools, electrical material, etc., 56,369,000 pesos against 52,756,000 pesos, and those of transport material, 40,786,000 pesos against 27,072,000 pesos. Details of the various items making up the totals in these three main groups are given in Table III, page 123. With regard to the main supplying countries of these three groups of imports, details for the years 1938 and 1936 are given in Table IV, and show the immense advantage enjoyed by Germany in those years through the operation of the *Aski* mark system, to the detriment of Britain. This implies a corresponding opening for these engineering lines from British exporters, now that German competition has disappeared. With the continued demand for transport material, imports thereof during the first four months of 1940 rose to 13,823,900 pesos from 13,098,000 pesos in the like period of 1939, while imports of metals and manufactures rose to 20,950,800 pesos from 17,595,000 pesos; but those of machinery, tools, electrical material, etc., fell from 18,648,000 pesos to 16,547,900 pesos.

Regarding British trade prospects in Chile, the latter will purchase British goods if prices and conditions are favourable, and it is likely that Chile may become increasingly dependent upon the British Empire both for imports and exports. Thus, British Government purchases of some 2,000,000*l*. of Chilean wool, meat, etc., in the spring of 1940 resulted, reciprocally, in a plentiful supply of sterling to pay for imports from Britain; but this is now drying up and, unless additional exports are made to the British Empire, there may again be difficulty in obtaining exchange cover for imports from the sterling area. The only remaining competitor is the United States, but the present shortage of dollar exchange is proving a great handicap for that country. However, delay in deliveries from Britain affects goods which are needed quickly, causing orders to go to the United States, while another factor working against British goods is the large number of reserve clauses contained in British contracts. The entry of Italy into the war has removed a strong competitor in such items as motor cars and bicycles. The items mainly in demand, apart from textiles, are iron and steel goods generally. Openings are reported for steel, enamel ware, razor blades, workshop tools, bicycles, and electric motors, as well as electrical fittings formerly supplied by Germany. If a British showroom were set up in Santiago for electrical fittings, it would probably have excellent prospects.

TABLE IV.—Chief Countries Supplying Engineering Products to Chile.

| | Value in Thousands of Pesos (of 6*d*. Gold). | | | | | |
|---|---|---|---|---|---|---|
| | Great Britain. | | United States. | | Germany. | |
| | 1936. | 1938. | 1936. | 1938. | 1936. | 1938. |
| Iron, steel and other metals and manufactures | 5,168 | 4,300 | 8,990 | 17,913 | 27,002 | 28,031 |
| Machinery, tools, electrical material, etc. .. | 5,224 | 6,316 | 23,547 | 27,162 | 19,103 | 26,226 |
| Transport material .. .. .. .. | 1,258 | 11,126 | 12,665 | 28,844 | 11,645 | 18,900 |

*(To be continued.)*

## THE DESIGN OF LIQUID EARTHING RESISTANCES.

By C. J. O. Garrard, M.Sc., A.M.I.E.E.

An earthing resistance is inserted in the neutral connection of a power-supply system in order to limit the current which flows upon the occurrence of a phase-to-earth fault. Under fault conditions, therefore, the resistance is subjected to a voltage equal to the phase-to-neutral voltage of the system, that is, to the line voltage divided by the square root of three. The best value of the resistance, and, therefore, of the current which flows under earth-fault conditions, depends upon the type of protective gear which is installed. The fault current must, of course, be sufficiently large to cause the earth-leakage or overload-protective devices to operate. It is customary, when the resistance is inserted in the neutral of one of a number of alternators, to make the current which the resistance can pass equal to the full-load current of the largest alternator. Similarly, if the resistance is used to earth the neutral of a transformer, it is designed to pass a current equal to the full-load current of the transformer. It can be assumed that, in general, the protective gear will operate with a delay which does not exceed a few seconds even under the most unfavourable conditions. In order, however, to have a substantial margin of safety, it is customary to design the resistance to carry the rated current for not less than 15 seconds or 30 seconds, according to circumstances.

From what has been said above, it follows that a neutral earthing resistance must first be capable of withstanding the application of the phase-to-earth voltage of the system without danger of flashing over and second, it must have sufficient thermal storage capacity to absorb the energy corresponding to its rating; this may be very considerable. Take, for example, a liquid resistance suitable for earthing the neutral of a 33-kV 30,000-kVA transformer. The full-load current of this would be 525 amperes, the phase-to-neutral voltage 19 kV, and the rating, say, 30 seconds. During such a short time as 30 seconds no appreciable loss of heat will take place. The whole of this energy must be stored in the resistance itself and dissipated slowly after the fault is cleared. As the resistance of the electrolyte decreases as the temperature increases and the current taken therefore increases in the same proportion, the energy to be stored is about 140 kWh, which is a large amount of energy.

Three main types of earthing resistance have been in general use. Resistances consisting of carbon powder in porcelain troughs, or of carbon plates in stacks, were used many years ago. The advantage of carbon as a resistance element for this purpose is that its resistivity decreases as its temperature increases. The fault current progressively increases as long as the fault persists, so that if at the beginning the current is not sufficiently great to operate the protective gear, the operation follows as soon as the fault current has attained a sufficient magnitude. The resistance, therefore, may be sufficiently high to protect the system against heavy faults and still ensure satisfactory operation of the protective gear on light faults. If the resistivity of the material used increases with temperature, as, for instance, is the case with cast iron, the fault current progressively decreases as the resistance gets hot, so that if at the beginning it is not sufficient to trip out the breaker, the breaker will not trip at all. It was found that for various reasons carbon was not a satisfactory resistance material. The carbon powder was apt to be thrown out of the troughs by the sudden heating and consequent expansion of the air, and the carbon plates were liable to fracture because they were not quite homogeneous. Any part which carried more current than another got hotter, and therefore carried still more current, with the result that the plate heated unevenly and cracked.

Resistances consisting of grids of cast-iron or steel stampings were, and still are, used to a great extent. Their main disadvantage is that they are expensive and bulky. They also require a considerable amount of attention, especially in the case of the cast-iron grids, as these are liable to break. Moreover, as mentioned above, the iron has a positive temperature coefficient of resistivity, which is a disadvantage for this application. Although theoretically it would be possible to increase the thermal capacity of a grid resistance by taking advantage of the high melting point of the iron, in practice it is not possible to do so on account of risk of fire. In the United States, grids of stainless steel have been used to some extent, but it would appear that the cost of these would be very high.

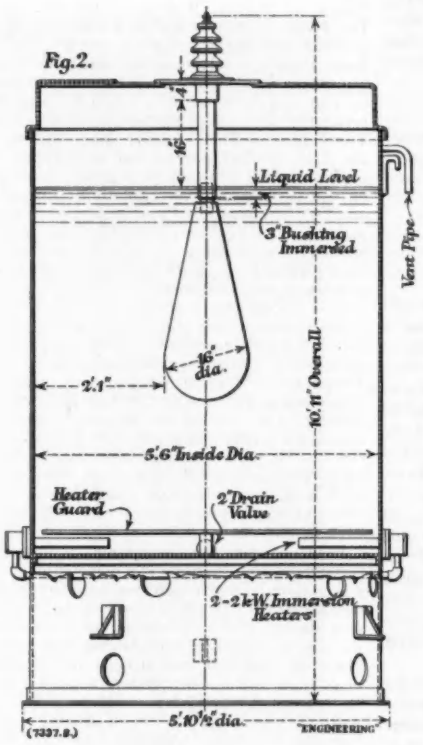
To overcome the various disadvantages inherent in the use of solid resistance materials, the liquid earthing resistance was introduced about fifteen years ago, originally by Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. The resistance is in the form of a cylindrical tank, the appearance of which is shown in Fig. 1, opposite, while its general design is illustrated in Fig. 2. This tank is filled with a suitable electrolyte, which is usually a solution of common washing soda, and forms the electrode on the earthed side of the resistance. The other electrode is suspended inside the tank by means of a bushing insulator and may be of various shapes depending upon the required resistance. Where the voltage is high and the necessary resistance correspondingly high also, then electrodes such as that shown in Figs. 3 and 4 have been found very suitable. These are so located that the centre of the hemispherical portion is equidistant from the bottom and sides of the tank. It is connected to the outside circuit through a bushing insulator, a typical design of which is illustrated in Fig. 5. Where a low resistance is required, it may be better to use a cylindrical electrode. These should not be employed, however, unless their diameter is at least equal to about two-thirds of the diameter of the tank; the diameter of the electrode should be equal to its height.

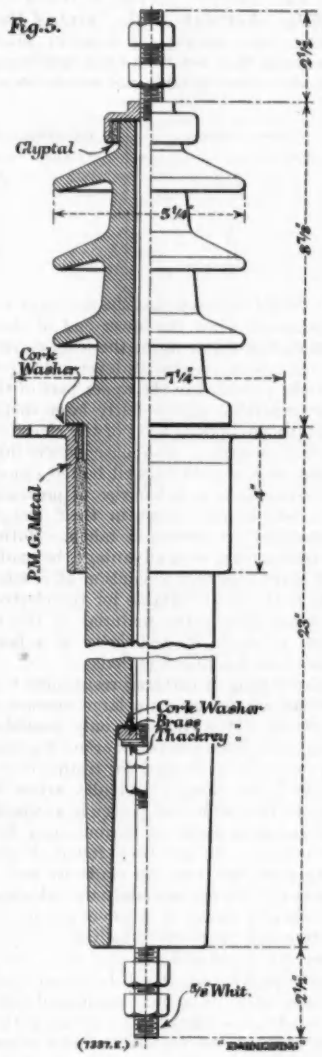
In order to prevent freezing in winter, the tank should be fitted with one or more small immersion heaters. These should be situated near the bottom of the tank and protected by a perforated plate bolted securely to the tank, as shown in Fig. 2. They are controlled by a thermostat, the construction of which is illustrated in Figs. 6 and 7.

Water has a high specific heat and can be used in a continuous body without any spaces such as must be left between the individual grids of a grid resistance for insulating purposes. The thermal capacity per cubic foot is, therefore, much higher than that of any other type of resistance. In addition, the resistance is simple and reliable, and, therefore, comparatively inexpensive. Experience over many years has shown that the electrolyte retains its specified resistivity over long periods, the only attention required being topping up from time to time and occasional measurement, and, if necessary, adjustment of the resistance.

# THE DESIGN OF LIQUID EARTHING RESISTANCES.

FIG. 1.



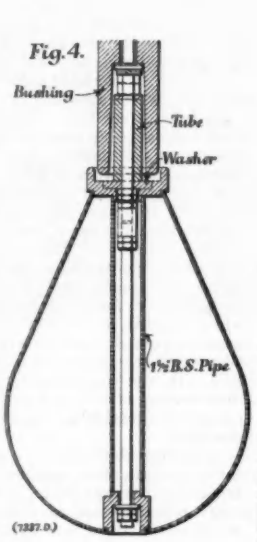
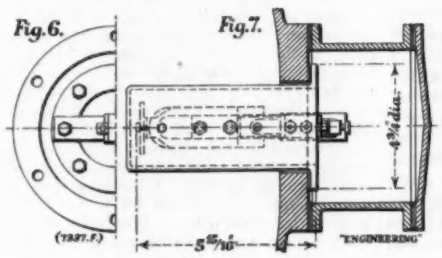



FIG. 3.




The basis for the design of a liquid earthing resistance must be the necessary thermal capacity of the electrolyte, and this must be calculated with due allowance for the progressive increase of the current as the electrolyte is heated. It is customary to specify a temperature rise of 50 deg. C. for liquid resistances. In these circumstances, it has been found that the average current which flows during the whole time that the voltage is applied is about 60 per cent. to 70 per cent. in excess of that which flows at first when the electrolyte is cold. Upon this basis the necessary volume of electrolyte may be calculated by means of the formula

$$V = \frac{E\,I\,t}{20\,T},$$

where V is the volume in gallons, E is the system voltage in kV, I is the rated current in amperes, $t$ is the time in seconds, and T is the temperature rise in deg. C. If T is 50 deg. C., as is most frequently the case, the formula reduces to the convenient form :

$$V = \frac{E\,I\,t}{1{,}000}.$$

The satisfactory operation of liquid earthing resistances depends upon the observance of two conditions : In the first place, the current density at the surface of the electrode must not exceed a certain value. Experience has shown that the current density may be between 0·5 ampere and 0·75 ampere per square inch, according to the voltage of the system. These current densities apply when the resistance is cold and the current has its minimum value. As the electrolyte is heated by the passage of the current, the current increases and so, necessarily, does the current density, but if the initial density is of the above-mentioned value, the final density will not reach a dangerous magnitude. In the second place, the voltage gradient through the electrolyte must not exceed a maximum value. The voltage gradient may be calculated in a manner similar to that used for calculating the voltage gradient in dielectrics and is equal at a given point to the product of the current density at that point and the resistivity of the electrolyte. The voltage gradient has its maximum value at the surface of the electrode, so that for the purpose of design the maximum figure in volts per inch is obtained by multiplying the current density at the surface of the electrode in amperes per square inch by the resistivity of the electrolyte, expressed in ohms per inch cube. In common with dielectrics, the greatest voltage gradient is found in contact with surfaces of small radius. For this reason, when designing the electrode of a liquid resistance, care should be taken to avoid sharp corners or parts of small diameter. It has been found from tests and experience that so long as the voltage gradient does not greatly exceed 3,000 volts per inch, satisfactory operation of the resistances is obtained. It should be observed that the voltage gradient does not alter as the resistance heats up because, although the current and therefore the current density increases in proportion as the electrolyte heats, the resistivity decreases in the same proportion so that the product of the two remains constant.

As regards construction, the most important point in the design of the tank is that it should be deep rather than wide and shallow. The centre of the electrode should be approximately at the centre of the main body of the electrolyte. In this way, good circulation of the electrolyte is ensured as the part of it which is in contact with the electrode becomes heated. The electrode should be smooth and rounded, especially in the case of high-voltage resistances. The construction shown in Figs. 3 and 4, which is covered by a provisional patent, has been found to be very effective as it contains no parts which have a small radius and yet enables the main part of the electrode to be placed well down in the tank without the use of thin supporting stems or unduly long and frail insulators. Provision should be made for a certain amount of evaporation of the electrolyte without the metal at the lower end of the bushing insulator becoming exposed. Satisfactory results will be obtained if 3 in. is allowed between the minimum electrolyte level and the bottom end of the bushing, as shown in Fig. 2, and a further 2 in. above the minimum level for evaporation.

It is important that the bushing insulator, the

design of which is shown in Fig. 5, should have adequate flash-over values, both at its upper and particularly at its lower end, where it is inside the tank and therefore subject to steam and possibly projected electrolyte in the event of the resistance coming into action on a heavy fault. It has been found that wet flash-over values in accordance with the following table, are satisfactory.

| System Voltage. | Wet Flash-over Voltage. |
|---|---|
| kV. | kV. |
| 11 | 30 |
| 33 | 55 |
| 66 | 106 |

It should be noted that the flashover values should be obtained when the lower end of the bushing is immersed in water up to the level corresponding to the maximum electrolyte level. Adequate venting must be provided in the upper part of the tank and it is preferable that a fairly large distance should separate the normal level of the electrolyte and the cover of the tank. Manhole covers or lids on the top of the tank should be well bolted down, as during operation there is a fair rise of pressure inside the tank which may result in their being blown off unless this precaution is taken. Both tanks and electrodes may, with advantage, be made of galvanised sheet iron and a solution of common washing soda is the most suitable for the electrolyte. This does not attack the material of the tank and is found to retain its resistivity at a fairly constant figure over prolonged periods.

The testing of earthing resistances is a somewhat difficult matter unless a large amount of power is available. It is therefore only possible to conduct tests either upon a network or in a high-power testing station, such as is used for testing circuit breakers. In the latter case, a difficulty arises because it is seldom that sufficient power is available to sustain the required value of current over 15 seconds or 30 seconds. It has been found, however, that a very good test may be made by first heating the electrolyte to approximately the calculated final temperature by means of steam or an electric immersion heater and then applying the voltage for a short time, say for 10 cycles to 15 cycles. If the resistance passes such a test, it will be found to operate quite satisfactorily on a more prolonged test which may be made on a network by starting with the water in the tank at the normal ambient temperature and heating it by the passage of the short-circuit current.

## HYDRO-ELECTRIC POWER IN ONTARIO.

The history of the Hydro-Electric Commission of Ontario during the thirty years of its existence has generally been one of considerable progress interspersed with a few setbacks. Perhaps the most important of the latter was brought about by the trade depression of a decade ago, though, in 1937-38, meteorological conditions caused a major breakdown of an important power station. This disaster was only partly offset by the ingenuity with which the damage was repaired. According to the 32nd report, the year ended October 31, 1939, can be classed as satisfactory. Before war was declared it became evident that industry was making progress towards better times. No serious interruptions occurred to the service on any part of the Commission's undertaking. The operation of all stations was unusually free from ice trouble, practically no loss in generating capacity resulting from this cause.

At the end of the year, the Commission was serving 856 municipalities, co-ordinated into four systems. Of these, the Niagara system is the largest and most important, embracing all the territory between Niagara Falls, Hamilton and Toronto on the east, and Windsor, Sarnia and Goderich on the west. It is mainly supplied with electricity from three stations on the Niagara River, with a total normal plant capacity of 830,000 h.p. This is supplemented by power from the Chats Falls station on the Ottawa River, which has a capacity of 108,000 h.p., and from the De Cew Falls station on the Welland Canal, which has a capacity of 50,000 h.p. In addition, there is a 24,000-h.p. steam station at Hamilton and power is also purchased from the Quebec companies. The Georgian Bay system comprises that part of the province which lies to the north of the Niagara system and derives its supplies from ten stations on the South Muskoka, Musquash, Severn, Beaver and Saugeen rivers. These have an aggregate capacity of 35,860 h.p., the largest being the 10,000-h.p. station at Ragged Rapids on the Musquash River. The Eastern Ontario system serves the whole of the province east of the foregoing systems. It is supplied from seventeen stations on the Trent, Otonabee, Sturgeon, Mississippi and Madawaska rivers. These have an aggregate capacity of 70,200 h.p., the largest being the 15,300-h.p. station at Heely Falls on the Trent River. The Thunder Bay system comprises the cities of Port Arthur and Fort William with the adjoining rural areas, and is supplied from two stations on the Nipigon River, totalling 103,500 h.p. In addition to operating these systems on behalf of the partner municipalities, the Commission holds and operates the Northern Ontario Properties in trust for the Province. The principal areas in this vast territory at present receiving service are the Nipissing District, centring round the city of North Bay; the Sudbury District, comprising the city of that name and the adjacent mining area; the Abitibi District, which is adjacent to the Sudbury District; and the Patricia-St. Joseph District, which comprises the territory within transmission distance of the Ear Falls station at the outlet of Lac Seul on the English River. In all, the maximum normal plant capacity of the Commission at October 31, 1939, was 1,525,000 h.p., and 5,795,479,615 kWh were generated, compared with 5,467,157,766 kWh in the previous year. In addition, 2,706,415,017 kWh were purchased, compared with 2,114,914,807 kWh in 1937-38.

Evidence of the increasing industrial activity throughout the Province was reflected in the increasing power loads. These increases became noticeable some months before the declaration of war and since that date have not only continued but have become augmented as plants manufacturing war materials have gradually increased their production. For instance, the demand on the Niagara system reached 1,228,000 h.p., an increase of 142,000 h.p., or 13 per cent., as compared with October, 1938, while in Northern Ontario the increase was from 1,484,615 h.p. to 1,669,337 h.p., or 12·4 per cent. This is explained by the development which has taken place in the mining fields of that part of the province where the total load increased by 18·6 per cent. This increase in output was met without any extensions being made to the generating plant of the co-operative systems, though additional pondage was provided at De Cew Falls, while to provide for the future, studies were made of possible power sites on the Musquash, Madawaska and Nipigon Rivers. The transmission and distribution systems were strengthened by the completion of a new transformer station, with an additional capacity of 50,000 kVA. in the Toronto district. A second transformer station, with a capacity of 67,500 kVA. was erected for the mills of the Ontario Paper Company at Thorold, while twenty-three new distributing stations were installed or were under construction and the capacity of twenty-five others was increased. About 31 miles of new transmission lines were placed in service and many revisions and improvements to existing lines were made.

It has been necessary for the Commission constantly to increase plant capacity and to develop the transmission systems, to provide for the growth in load in the mining areas served by the Northern Ontario Properties. The increase in the power demand from both existing and new mining properties has been so rapid that it has been difficult to provide plant and equipment fast enough to prevent any hampering of mining operations from the standpoint of power supply. Among the work done to improve these conditions mention may be made of the linking up of the Patricia and St. Joseph districts with the object of effecting operating economies and providing better regulation, so as to safeguard essential power supplies in the event of breakdown to the generating plant either at Ear Falls or Rat Rapids. It will also enable the growing power demand of both districts to be met by extending the former station. This station is situated at the outlet of Lac Seul, across which a conservation dam is built to give a reservoir of some 4,500,000 acre-ft. Originally, this dam was built to regulate the outflow of the lake, but while it was being constructed, ten years ago, the opening up of near-by mining properties justified the immediate provision of a power station. At first one and then another 5,000-h.p. fixed-blade propeller turbines were installed to operate on a head of 36 ft., but the third set, which has just been installed, is of the Kaplan type, with an automatically-adjustable blade runner and has an output of 7,500 h.p.

As in former years, considerable developments have taken place in the rural electric services. About 35,687 sq. miles of the 363,282 sq. miles forming the Province of Ontario are utilised for agriculture and the population in the rural areas served by the Hydro-Electric Commission is about 1,100,000. During the past year, 2,364 miles of rural line were approved for construction and 13,235 consumers were added. The aggregate load supplied to all rural consumers in the Province amounted to 61,634 h.p., an increase of 15·5 per cent. over 1938. There are about 200,000 farms in Ontario, but there are various reasons for supposing that not more than 75,000 of these could be served on the present basis of three farms per mile of primary transmission line.

## DAYLIGHT ILLUMINATION FOR CLERICAL WORK.

The attention of the Department of Scientific and Industrial Research has been called to apparent differences in the findings of *Illumination Research Technical Papers Nos.* 7, 12 *and* 19, and it has been asked whether these differences can be reconciled, or whether No. 19 supersedes the earlier papers. We have received the following official explanation from Mr. T. Smith, Superintendent of the Light Department, National Physical Laboratory.

Paper No. 7 (*Penetration of Daylight and Sunlight into Buildings*),* which was first published in 1927, is largely concerned with the calculation of daylight factors and a "minimum tolerable" value of daylight factor of 0·2 per cent. was proposed. The Illumination Research Committee, in publishing this paper, substantially endorsed the views expressed by one man with long experience of illumination problems. It was made clear that a higher standard was required for certain purposes; for instance, a daylight factor of 0·5 per cent. was mentioned as that on the worst desk of approved elementary-school class rooms. Paper No. 12 (*The Daylight Illumination Required in Offices*)† was issued in 1931 and gave the views of a "jury" composed of architects, illuminating engineers and others, and the minimum tolerable daylight factor for a number of rooms of various shapes and sizes. The view of the occupier of each room was also obtained. The value reached was substantially 0·2 per cent. These rooms were used for ordinary writing. Some misapprehension has arisen from a wrongly worded sentence in this paper. The "jury," of which the author of the paper was not a member, were investigating minimum tolerable values of daylight and did not express the view that natural lighting in a clerical office might be regarded as adequate where the daylight factor was equal to or exceeded 0·2 per cent. It is noteworthy that such a view was expressly rejected by the International Commission on Illumination when it discussed problems of interior illumination in the same year.

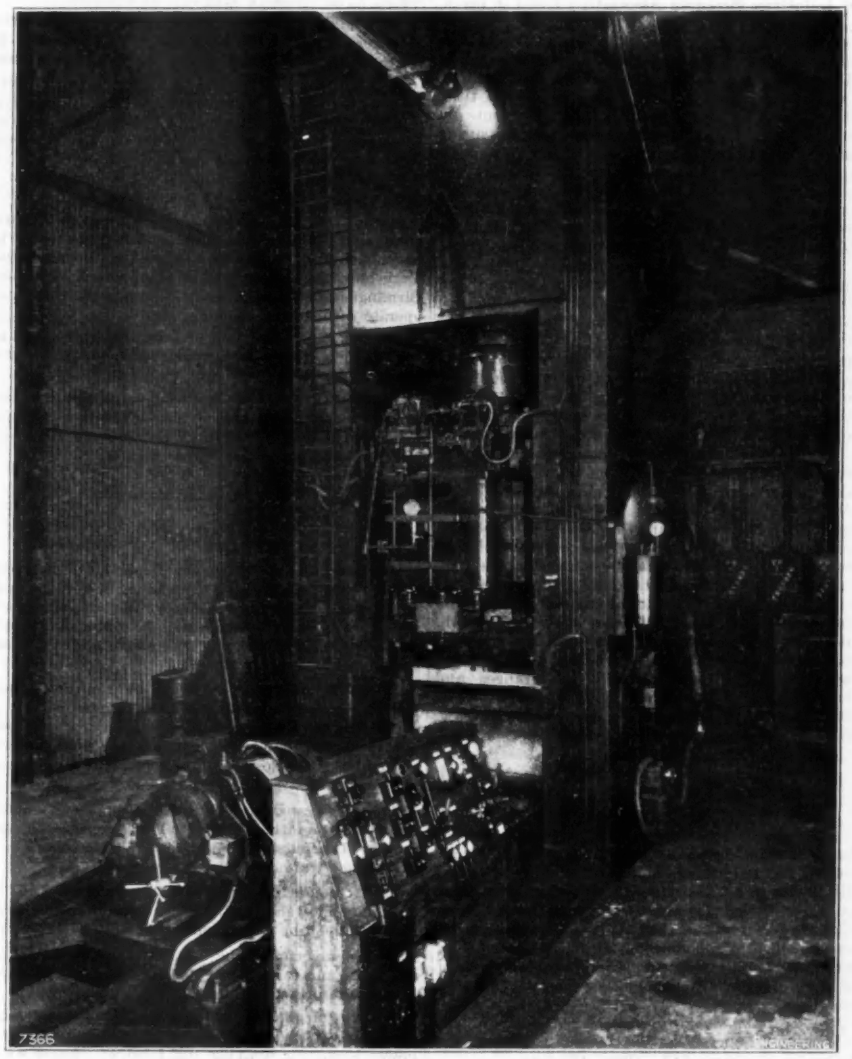
The investigation of 1937 described in Paper No. 19 (*Daylight Illumination Necessary for Clerical Work*), differed from the other two in that the workers in the normal course of their duties provided—perhaps unconsciously—the data on which the conclusions were based. The value reached—5 ft.-candles—corresponds to a daylight factor of 1·0 per cent. on a dull day, when the outside illumination is 500 ft.-candles. The work concerned was typewriting, and this word could with advantage have replaced "clerical work" in the title. In view of references in the paper to artificial illumination, it may be well to state definitely that the conclusions reached in the investigation only related to daylight.

It is probably fair to say that, in the first two investigations, the emphasis tended to be on illumination that was inadequate for clerical work and other purposes that may be classified as stationary; and, in the third, on illumination needed to carry out typewriting and other rapid operations efficiently. As might be expected, the personal factors, as revealed in the second and third papers, are rather large, but there is no reason to suppose that the third misrepresents the standard of illumination that should be secured for typewriting and similar work. Such operations necessitate a higher minimum of illumination than comparatively slow processes, such as handwriting. It is not surprising that the standard of illumination generally expected—now easily obtained—has increased. The position was concisely summarised in the chairman's Prefatory Note to the last of these papers: "Some of the minimum standards of illumination suggested in the past are much too low." This, of course, does not imply that there are no conditions for which a lower standard of illumination than is necessary for efficient typewriting is adequate.

South African Institution of Engineers.—At the annual general meeting of the South African Institution of Engineers, held recently in Johannesburg, it was announced that there were 538 members on the roll of the Institution, as compared with 524 on June 1, 1939.

* See Engineering, vol. 125, page 401 (1928).
† See Engineering, vol. 132, page 272 (1931).

# REMOTE CONTROL FOR POWER PRESS.




## REMOTE CONTROL FOR 1,500-TON POWER PRESS.

THE crankless power press made by Messrs. Clearing Machine Corporation, 6499, West 65th-street, Chicago, U.S.A., lends itself well to remote control, this form of control being, in some cases, desirable, and in the accompanying illustration a recent application of this control is shown. The Clearing press, it may be recalled from the description of it given in ENGINEERING, vol. 148, page 481 (1939), has its ram actuated by eccentrics driven by geared-wheels deriving their power from an electric motor. The transmission shaft is fitted with a combined air-operated friction clutch and brake, and the adjustment of the platen relative to the ram is effected by a small auxiliary motor. In addition, either air-cushions or hydro-pneumatic cushions are fitted and, in some instances, locking devices operated through either a rotary valve actuated by a moving member of the press or by individual solenoid valves, are provided. It will thus be clear that a number of controls are involved, their number resulting in the unusual flexibility of the press.

The press described in the article cited above was one of 900 tons, and had a large platen with a ram at each corner, as it was used for such purposes as shaping parts for motor-car chassis and bodies. The press now dealt with is of 1,500 tons and has a single ram only, the platen being relatively small, since its duty is to swage forgings from aluminium-alloy billets. There is, moreover, an air-operated billet-handling table capable of both longitudinal traverse and rotation. The remote-control panel was designed and installed by the technical staff of Messrs. High Duty Alloys, Limited, and is prominent in the foreground of the illustration. As will be evident from this, the panel is constructed of wood, but an internal steel frame is employed. It is about 4 ft. 6 in. in height and is 5 ft. long, the working surface being sloped back, desk fashion, for convenience of operation. The several pipes and electrical leads are run underneath the floor to the unit concerned, but all are accessible and each is clearly marked for identification purposes. The panel is situated at one side of and parallel with the traverse table, a position which gives the operator a clear view of the swaging and rotating of the billets, the latter motion being automatic and being co-ordinated with the movements of the press ram. Ease of operation of all controls is facilitated by the close grouping of the various switches, etc., each of which is identified by a clearly lettered label, while, where a pressure gauge is necessary, it is grouped with its appropriate control.

Dealing with the arrangement of the controls from left to right in the illustration, the main switchgear is seen on the vertical face of the panel. Above this are the controls for the press clutch and brake, these controls enabling either continuous or intermittent movement of the ram to be made. Next to these are seen three pairs of push-buttons, one above the other. These control the starters for the motors of the oil pump for the cushioning device, the crosshead adjustment, and the lubricating pump. The next group consists of four tumbler switches on the lighting circuits for inspection, and so forth; for example, the lamp seen at the top of the press which illuminates the oil-level window of the oil bath, in which the eccentric and its driving gear works. In the centre of the panel at the top is a thermostatically-controlled red light, which glows should overheating of the oil in the cushioning chamber take place. The remaining electrical controls on the panel are the in-feed and the inching feed of the traversing table, the in-feed being continuous or intermittent, as desired.

The several control levers actuating the air-operated movements, viz., table in-feed, speed control and knock-out bars, are situated at the right-hand side of the panel, the table traverse being regulated by a lever having forward, backward and neutral positions, and its speed being controlled by a needle valve. In each case a pressure gauge is arranged close to the control dealt with. A lever is also used for the operation of the knock-out bars, and is situated so as not to interfere with the other controls on the panel. Two pressure gauges, which it is not necessary to place on the panel, are fitted on the press itself, as is clear from the illustration, one of these being at the side close to the air receiver and the other near the platen. Both can readily be seen by the operator at the panel. Though, admittedly, the arrangement described and illustrated here is only a particular example, it is interesting in that it serves to show what may be done to control the Clearing power press from a single point. It may be noted, in conclusion, that the British agents for this type of press are Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9.

## THE ALKALI ACTIVATION OF GAS COKE.

IN the current issue of *Smokeless Air*, the journal of the National Smoke Abatement Society, a succinct account is given of a paper entitled "The Production of Reactive Gas Coke by Alkali Activation," which paper was intended to be read at the annual general meeting, now postponed, of the Institution of Gas Engineers, by Mr. H. H. Thomas, B.Sc., and Mr. P. J. Askey, B.A. Some comments on the paper are given below.

It will be recalled that a free-burning coke suitable for ordinary open fires was introduced under the name of "Dryco," some ten years ago, by Messrs. Liverpool Gas Company. The fuel was produced by blending coals and modifying carbonisation conditions, and is sold in the immediate area at the rate of about 17,000 tons a year. The gaseous thermal yield from the coals normally used is, however, low and difficulties arise in obtaining suitable coals. The process referred to in the paper enables free-burning coke, which does not need a special type of grate, to be produced from a greater range of gas coals than that from which "Dryco" is produced, without increase in gas prices. The reactivity of solid fuels to oxygen, $CO_2$ and steam is increased when small amounts of certain alkali-metal salts are added.

The operations involving this addition of an alkali have been carried out on a works scale for seventeen months at the Garston Gas Works, Liverpool, the alkali used being sodium carbonate and being added to the coal before carbonising. Alternatively, it may be added to the coke after carbonising. Apart from the sodium carbonate, some lime is also added in order to combine with the clay constituents normally present in the coal ash so that a smaller quantity of the more expensive sodium carbonate, which has the same power of combination, is needed. The amount of lime required depends upon the nature and quantity of the ash. The ash in the activated coke is increased by the added alkali by an average amount of about 6 per cent. or 8 per cent. It may be noted that the average ash content of "Dryco" is 6 per cent., but the ash from the activated coke is denser, so that the volume of ash from a given weight is the same in both fuels. A table, given in the paper, of the characteristics of the alkali-activated coke compared with "Dryco" as made at two different works of the gas company, and a typical low-temperature coke, shows that the first-mentioned fuel compares very well with the others. During the test period referred to above, approximately 6,000 tons of activated coke were produced and sold, either by itself or mixed with "Dryco," and its reception carefully noted. Some complaints of excessive ash and poor reactivity were received, the former being traced to undue amounts of shale in occasional deliveries of coal and the latter, for the most part, to uneven grading arising from segregation in the coal bunkers. Occasionally, inactivity has been found to arise from insufficient wetting of the coal before adding the alkali with resultant partial segregation of the alkali. Two-stage heating in the retort resulted in a definite improvement in the reactivity of the coke, this confirming the generally accepted view that over-carbonising must be avoided.

The first part of the paper gives particulars of the methods evolved for adding the alkali mixture to the coal, and later the authors deal with the cost of gas production under "Dryco" and alkali-activation conditions of carbonisation. The ultimate success of the later process depends upon the cost of gas production, which is the lowest for this method, taking into account the different treatments needed for the several processes and the marketability of the cokes produced. This latter involves the economic balancing of the demands for gas and coke, the supply of the former determining the output of the latter. It may ultimately be found,

for instance, that domestic coke sales may be profitably increased to a point at which the coal is carbonised primarily for the production of coke. This procedure would involve gas production greater than the demand, in which case the excess gas would be used for heating the retorts. It is scarcely necessary to point out that the procedure of carbonisation primarily for coke would greatly reduce the amount of raw coal burned in domestic grates, a condition much to be desired from the point of view of the reduction of atmospheric pollution. At present, however, the carbonising industries are quite unable to supply smokeless fuel in the quantity or quality which an increased demand would require, and what is needed, therefore, is an effort to improve the quality of the coke so that the resultant greater demand will enable a method of production to be adopted which will reduce the costs of gas production. The work described in the paper seems to be a substantial contribution to the desired end.

Two other parts of the paper are of interest. The first relates to the activation of coke after carbonisation. Early attempts in this direction were attended with difficulties, such as that of controlling the amount of sodium carbonate added and the formation of a white surface when coke dipped in a solution of it was dried. More recent work consists of discarding the dipping method and applying the solution in a fine spray. So far, success seems to lie in avoiding flooding of the coke surface, the most promising technique being to use a very fine spray in such a quantity that the coke will absorb it continuously and the amount of solution remaining on the surface will be only sufficient to cause a general lightening in the normal grey colour. Coke thus treated has no loose surface deposit which can be lost or become a nuisance in subsequent handling. In order to present continuously-changing surfaces to the spray, the pieces of coke should be kept moving in the spray mist. The authors are careful to point out that this particular investigation is by no means completed, and that a good deal more work is needed before this method of applying alkali activation can be completely established, while transference of the process to full works scale is likely to be attended by difficulties. Since, however, this alternative method of applying alkali activation avoids any possible damage to retort refractories, it is considered that the preliminary results are deserving of some attention. The second of the two points referred to above is concerned with the production of a sufficiently reactive coke to give a good gas for use in producer-gas vehicles. Tests showed that neither "Dryco" nor alkali-activated coke was, by itself or in combination, satisfactory, but it was found that when alkali was added to "Dryco" a considerable increase in reactivity resulted. The fuel thus prepared met the provisional specification for producer fuels published by the Mining Association of Great Britain. More recently, the fuel prepared by the spray-impregnation method has been found to give a gas virtually identical in composition and calorific value with that obtained from good quality low-temperature coke, which is already recognised as among the best producer fuels available.

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Panama-Canal Traffic.—During the twelve months ending May 31, 1940, vessels to the number of 5,480, carrying 27,947,320 tons of cargo, passed through the Panama Canal, compared with 5,889 ships carrying 27,517,929 tons of cargo in the preceding twelve months.

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"Doodlebugs and Bulldozers." Erratum.—We regret that, in quoting from the *Dictionary of American Slang*, in the article, "Doodlebugs and Bulldozers," on page 112, *ante*, we spelt incorrectly the name of its compiler, Professor Maurice H. Wescen, of the University of Nebraska.

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Rubber and Tin Exports from Malaya.—It is stated in *The Board of Trade Journal* that ocean shipments of rubber and latex from Singapore, Penang, Malacca and Port Swettenham, in July, totalled 70,360 tons, of which rubber comprised 68,142 tons, and latex, concentrated latex, revertex and other forms of latex, 2,218 tons. Shipments of tin, in July, amounted to 9,640 tons.

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Fire Extinguishers and Incendiary Bombs.—The Ministry of Home Security informs us that its attention has been drawn to the sale to the public, for use as fire extinguishers, of appliances consisting of a quantity of liquid in a small glass globe. Although these appliances may be effective in dealing with ordinary fires, it is emphasised that they cannot be relied upon for extinguishing incendiary bombs. Moreover, some of them are filled with a fluid which would generate a poison gas if brought into contact with an incendiary bomb and would, therefore, be very dangerous to use in a confined space in which a bomb was burning.

## THE MEASUREMENT OF WARMTH.

As a preliminary to some investigations on space heating by electricity, the British Electrical and Allied Industries Research Association found it necessary to decide what methods should be used for appraising warmth and comfort. The results of this investigation are to be found in a critical résumé by Mr. D. V. Onslow, which has now been published by the Association at the price of 5*s*., under the title, "Methods of Measuring Warmth in Experiments on Space Heating." The following methods of measuring warmth, either singly or in combination, are dealt with:—The ordinary thermometer to measure air temperature; the kata-thermometer to measure air velocity and cooling power, and also equivalent temperature; the globe thermometer to measure the combined effects of air temperature and radiation, and, in combination with the ordinary and kata-thermometer, to estimate equivalent temperature; and the empatheoscope, to indicate the combined effects of temperature, movement of the air and radiation (equivalent temperature).

The requirements for satisfactory heating and ventilating are that a suitable degree of warmth should be maintained, that the heads of the occupants should not be exposed to excessive radiant heat, and that the air at head level should not be appreciably warmer than that near the floor. The air should also be moving rather than still, and its rate of movement should be variable rather than uniform and monotonous. There should be no local draughts and the walls should preferably be warmer than the air. The relative humidity should be reasonably low, preferably below 70 per cent., and the air should be free from odours. The measurement and effect of air temperature, air velocity and movement, rate of air change, cooling power, radiation and humidity are fully dealt with, details being given of the various measuring instruments and temperature scales which should be employed. Indications are given of the ranges and combinations in which comfort may be ensured. The utility of the report will be increased by an exhaustive bibliography of the authorities consulted.

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## BOOKS RECEIVED.

*A Primer of Time Study.* By F. W. Shumard. London: McGraw-Hill Publishing Company, Ltd. [Price 33*s*.]

*United States War Department.* Miscellaneous Series No. 4. *Port and Terminal Charges at United States Great Lakes Ports.* 1940 edition. Washington: Superintendent of Documents. [Price 30 cents.]

*Ledamotsförteckning för Svenska Teknologföreningen. February*, 1940. Stockholm: Svenska Teknologföreningen.

*The New Techniques for Supervisors and Foremen.* By Professor Albert Walton. London: McGraw-Hill Publishing Company, Ltd. [Price 16*s*. 6*d*.]

*An Air-Conditioning Primer.* By W. H. Stangle. London: McGraw-Hill Publishing Company, Ltd. [Price 16*s*. 6*d*.]

*Procedure Handbook of Arc Welding Design and Practice.* Sixth edition. Cleveland, Ohio, U.S.A.: The Lincoln Electric Company. [Price 1·50 dols.] Welwyn Garden City, Herts: Lincoln Electric Company, Ltd. [Price 9*s*. 6*d*.]

*American Society for Testing Materials.* Volume 39. *Proceedings of the Forty-Second Annual Meeting, Held at Atlantic City, N.J., June 26-30, 1939. Committee Reports and Technical Papers.* Philadelphia, Pa., U.S.A.: American Society for Testing Materials.

*Aircraft Maintenance.* By D. J. Brimm, Jun., and H. E. Boggess. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s*. 6*d*. net.]

*United States National Bureau of Standards.* Handbook H26. *Safety Rules for Electric Fences. Comprising Part 6 of the Fifth Edition, National Electrical Safety Code.* Washington: Superintendent of Documents. [Price 5 cents.]

*United States National Bureau of Standards.* Miscellaneous Publication M164. *Report of the Twenty-Ninth National Conference on Weights and Measures, Held at the National Bureau of Standards, Washington, D.C., June 6, 7, 8 and 9, 1939.* Washington: Superintendent of Documents. [Price 25 cents.]

*United States National Bureau of Standards. Building Materials and Structures.* Report BMS44. *Surface Treatment of Steel Prior to Painting.* By R. E. Pollard and W. C. Porter. Washington: Superintendent of Documents. [Price 10 cents.]

*Penton's Almanac*, 1940-41. *Facts and Figures for the Ferrous and Non-Ferrous Metal Producing and Consuming Industries.* Penton Building, Cleveland, Ohio, U.S.A.: The Penton Publishing Company.

*Boiler House and Power Station Chemistry.* By Dr. Wilfrid Francis. London: Edward Arnold and Company. [Price 15*s*. net.]

## PERSONAL.

Mr. Harold Savage, B.Sc. (Eng.), A.M.Inst.C.E., has been appointed new works assistant, Chief Engineer's Office, Great Western Railway, Paddington.

Mr. W. H. Victory, assistant to the Chief Docks Manager, Great Western Railway, Cardiff, has been elected chairman of the Newport Harbour Commissioners.

Mr. R. Hugh Roberts, who was formerly Deputy Director-General of Equipment and Stores, Ministry of Supply, has been appointed Director of Machinery Licensing. He will be responsible for the licensing of machinery and plant under the Machinery and Plant (Control) (No. 2) Order, 1940. His office is at 25, Southampton Buildings, Chancery-lane, London, W.C.2.

Messrs. J. H. Fenner and Company, Limited, announce that although their main Vee-rope sales division has moved from Hull to Beck-lane Mills, Heckmondwike, Yorkshire, the branch offices in London, Manchester, Birmingham, Glasgow and Belfast will continue to operate without any change.

Messrs. C. S. Meik and Halcrow have removed from 16, Victoria-street, to Alliance House, Caxton-street, London, S.W.1.

Mr. W. H. Greaves has been appointed representative for Scotland of Messrs. Edgar Allen and Company, Limited, Imperial Steel Works, Sheffield, 9. He succeeds Mr. A. MacPhail, who retired recently.

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## TENDERS.

We have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

*Telephone Material*, including transmitters, mouthpieces, plugs and terminal covers; September 3. Also condensers of various capacities, interference suppressors, and head sets, hand sets, diaphragms, rings and nuts; September 5. Posts and Telegraphs Department, Melbourne, Australia. (T. 21,223/40.)

*Transformers*, two, 2,000-kVA oil-immersed, outdoor-type, having a ratio of 33,000 to 11,910 volts. Electricity Supply Commission, Cape Town; October 8. (T. 21,222/40.)

*Cable*, enamel-insulated, cotton-covered and lead-antimony alloy sheathed. Posts and Telegraphs Department, Melbourne; September 10. (T. 21,127/40.)

*Switchgear*, comprising distribution boards, switches and fuses, and switch boxes. Union Tender and Supplies Board, Pretoria; October 3. (T. 21,239/40.)

*Weaving Machines* for trades and industrial schools, including witch dobbies for hand-loom mounting; power looms for weaving silk fabrics; cheese winder; piano card-cutting machines; cutting, lacing and sewing machines for tricot cloths; and hand knitting machines. Ministry of Education, Sharia El Falaki, Cairo, Egypt; September 4. (T. 21,229/40.)

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Tapered-Roller Bearings: Erratum.—In our article on the tapered-roller bearings made by Messrs. British Timken, Limited, for the 36-in. centre Craven tube-boring lathe, and published on page 107, *ante*, it was stated that the motor for the feed and quick traverse of the boring bars and carriages was of 100 h.p., which figure, it will be obvious, should have been 10 h.p.

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The Control of Magnesium.—The Minister of Aircraft Production has made an Order, entitled The Control of Magnesium (No. 1) Order, 1940. This provides that magnesium and its alloys, whether unfabricated or in the form of billet, block, powder, slab or stick, shall not be bought, sold, or used except under licence. Information on the subject may be obtained from the Ministry of Aircraft Production, Light-Metals Control, Southam-road, Banbury, Oxon.

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Lloyd's Register Scholarship.—The scholarship, valued at 100*l*. per annum and tenable for three years, awarded annually by Lloyd's Register of Shipping on the results of the studentship examination of the Institute of Marine Engineers, has, this year, been awarded to Mr. Bryan Hildrew, aged 20, of Roker, Sunderland. Mr. Hildrew is an apprentice engineer in the employ of Messrs. North Eastern Marine Engineering Company, Limited, and has been undergoing an engineering course of study, on the sandwich system, at Sunderland Technical College, where he will now commence full-time study for the honours Degree in Engineering of London University.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Welsh Coal Trade.*—The curtailment that took place in production generally last week has resulted in offers of most descriptions being rather less freely made on the Welsh steam-coal market. There was, however, no shortage of any description but although operators were able to cover their immediate needs without difficulty, sellers were not pressing and the general tone was consequently very steady. It was reliably reported on the market that the agreement concerning the exchange of Portuguese pitwood for Welsh coal would soon be announced. Negotiations have been proceeding for some time and, as a result, it has been estimated that Portugal would take something like 750,000 to 1,000,000 tons of Welsh coal per annum, while local collieries would take all the mining timber Portugal could offer. Moderate interest was shown on the market on Spanish account but it was not thought likely that buyers in this trade would make heavy forward purchases. It seemed, for the present, that they would be content to cover only their immediate pressing needs and there was little indication that they would reverse this policy for some time. Activities were well maintained in the South American and Canadian trades and deliveries to Eire were still considerable. The chief activity, however, continued to be displayed in the inland trade. There was a sustained request from this direction and the deliveries being made continued to absorb almost the whole of the present production. Best large descriptions were steadily absorbed but the popular sized kinds were still only quietly offering. Bituminous smalls were fairly active, but the dry smalls were slow. Cokes and patent fuel were active.

*The Iron and Steel Trade.*—Busy conditions again ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. There was a rather better demand on export account for tin-plates.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel*—Progress in the steel and engineering trades is uniform and outputs continue to rise. The labour position is satisfactory, more men having been withdrawn from non-engineering work and given employment in the big works. Sheffield University continues to train more women in repetition work and large numbers have been engaged in the tool-making and light-engineering industries. The raw and semi-finished steel branches continue to be actively employed. There is an extensive demand for basic-steel billets. Inland needs are substantially greater than was the case a year ago and only a limited tonnage is going abroad. Acid steel is in strong request, and steel-making alloys are being consumed in larger quantities. This is not surprising in view of the heavy demand for all types of special steels for Government orders. The scrap market is lively, and supplies are ample to meet all requirements. Orders are more numerous in the heavy-machinery and engineering branches, a bright feature being the increase in overseas trade. The Colonies and Dominions are good customers, and efforts to stimulate trade with South American countries are meeting with success. The demand for steelworks' and ironworks' machinery and related equipment has been well maintained. Heavy forges are satisfactorily employed in the production of forgings of record size and weight in connection with electrification and hydrogenation schemes. Heavy grinding machinery is a progressive line; South African mining enterprises are valuable customers in this type of plant. Steel balls for crushing purposes are in strong demand. British collieries are buying all types of underground plant more freely. Among the lines in demand are steel arches and girders, steel tubs, pneumatic drills and picks, shovels, and winding and haulage gears. Progress is being made by manufacturers of high-efficiency steels, the output of stainless steel being extremely high. Supplies are only available for makers of cutlery for export, the result is that the bulk of production is being used for the manufacture of products of national importance. High-speed steels are in strong request, and the market in tool steels is exceptionally brisk. Overseas needs are increasing. The tool-making branches are actively employed. Among the lines in demand are engineers' tools, files, saws, rasps, reamers, jigs, twist drills, and hacksaws and blades. A good trade continues to be done in farm and garden tools.

*South Yorkshire Coal Trade.*—Increased outputs are reported by the majority of collieries in this area, forward buying being a feature of the business being done. Industrial coal is in strong demand, and steams are a satisfactory section. The railways are taking larger tonnages of locomotive coal. House coal is in strong request. Power stations are also buying supplies of smalls and slacks for stocking purposes. The coke market shows little change.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*General Situation.*—While there is little scope for ordinary business in iron and steel after the requirements of consumers engaged on war work have been met, the maintenance of a heavy aggregate tonnage output promises to provide for a gradual increase in the material available for other purposes. Home buyers are anxious to negotiate for supplies for industrial purposes and overseas customers have substantial orders to place. Export licences are less difficult to obtain than has been the case for some time past and shipments of certain commodities to distant destinations are expected to improve considerably. A gratifying feature of the present situation is that satisfactory supplies of raw materials continue to arrive.

*Cleveland Iron Trade.*—The position as regards Cleveland pig is unchanged. Saleable parcels are few and small and there seems no likelihood of an early increase in the present output. The supply, however, continues to be supplemented by deliveries from other foundry-iron producing centres to an extent which is sufficient to meet current needs. Most of the tonnage passing into use on the North East coast is from the Midlands. Parcels of Scottish iron are still obtainable for specific purposes. The recognised values of Cleveland pig remain at the equivalent of No. 3 quality at 120*s.*, delivered within the Tees-side zone.

*Hematite.*—The heavy and increasing demand for East Coast hematite is taxing the resources of the makers, whose obligations are extensive and pressing. Buyers have substantial contracts, under which considerable supplies are due, and are insisting on full deliveries; but the absorption of tonnage at the producers' own consuming departments is difficult to keep pace with. Every effort is being made to increase output and makers are hoping to be able to cope with the entire needs of the consumers. Merchants see little prospects of adding to the moderate tonnage they now possess. The stabilised quotations are at the level of No. 1 description of hematite at 131*s.*, delivered to North of England areas.

*Basic Iron.*—The price of basic iron remains nominal at 113*s.* Producers are turning out ample tonnage for the requirements of their steel-making plants, but have none to spare for other users.

*Foreign Ore.*—Stocks of foreign ore remain at a very high level and adequate supplies continue to come to hand.

*Blast-Furnace Coke.*—As sellers of Durham blast-furnace coke have well-filled order books and the requirements of local users are extensively covered, new business is confined within narrow limits; supplies, however, are plentiful. Fixed prices are ruled by good medium qualities at 33*s.* 5*d.* at the ovens.

*Manufactured Iron and Steel.*—The make of semi-finished iron and steel, together with substantial imports, are sufficient for the requirements of the re-rolling mills, all of which are fully employed. In the finished industries interest centres on steel production, which has to be maintained at a very high level to meet the demand. Much of the material is supplied to firms engaged in constructional work and to the shipyards. Among the principal quotations are: Soft steel billets, 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets, 11*l.* 17*s.* 6*d.*; joists and angles, 13*l.* 13*s.*; heavy plates, 14*l.* 3*s.*; and boiler plates, 15*l.* 0*s.* 6*d.*

*Scrap.*—A further improvement in the supply of iron and steel scrap is enabling users to replenish their stocks. All available parcels are readily taken up.

THE AUSTRALIAN GOLD-MINING INDUSTRY.—The production of gold in the Commonwealth of Australia, during the first quarter of the present year, totalled 401,178 fine oz., against 366,611 oz. in the first three months of 1939 and 363,289 oz. in the period January to March, 1938.

THE UNITED STATES STEEL INDUSTRY.—The production of steel ingots in the United States, during the third week in July, is reported to have been equivalent to 86·8 per cent. of the capacity of the steelworks. This figure is slightly below that for the last week in June, but, with that exception, is the highest since December, 1939.

CONSUMPTION OF IRON AND STEEL SCRAP IN THE UNITED STATES.—According to statistics published by the Institute of Scrap Iron and Steel, New York, 3,482,000 gross tons of scrap were consumed in American steelworks during June, compared with 3,061,000 tons in May, and 2,221,000 tons in June, 1939. In the first six months of the present year 18,212,000 tons of scrap iron and steel were consumed, against 13,214,000 tons in the first half of 1939.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—There is little to report on the Scottish steel trade, except that record outputs are still general. The shipyards continue to absorb a large tonnage. Although the greater part of the present output of steel is required for Government work, a certain proportion is available for machinery for export, chiefly to the Dominions. Practically all the engineering works are very busy. A feature of importance is that there is a very good supply of scrap and full-time working is general in the steel industry. Makers of black-steel sheets have a large amount of work on hand, and production is on a maximum scale. The following are the current market quotations:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised sheets, plain, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and corrugated, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

*Malleable-Iron Trade.*—Conditions in the West of Scotland malleable-iron trade are very satisfactory at present and, with order books well filled, the works are fully occupied. The re-rollers of steel bars are exceptionally busy. Ample supplies of semi-manufactured material have been arriving during recent weeks, but the tonnage of the smaller billets has not been so heavy. Arrangements have now been made to ensure that forward shipments will include all sizes required by the British re-rolling industry. The market prices are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton, untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

*Scottish Pig-Iron Trade.*—All the furnaces in commission in the Scottish pig-iron industry are operating at full capacity, and the whole production is speedily taken up. Stocks of iron ore are ample for all requirements, and recent shipments of considerable tonnage are adequate for the immediate future. While the demand for hematite and basic iron is exceedingly strong, that for foundry grades is only moderate, although there is a tendency to improve.

EXTENSIONS AT PURDUE UNIVERSITY.—A new chemical and metallurgical-engineering building has recently been opened at Purdue University, in the United States. This is a three-storeyed structure, having a floor area of 78,952 sq. ft. Two-thirds of the available space is to be devoted to chemical-engineering laboratories, workshops, lecture rooms, etc., while the remaining one-third will be used by the metallurgical-engineering department. The equipment includes large steel-melting electric furnaces, a billet-reheating furnace, an 8-in. by 12-in. rolling mill, and an ore concentration plant having a capacity of 300 lb. of ore per hour. For instruction and research in electro-metallurgy, a 1,200-ampere single-phase motor-generator set, another to furnish 500 amperes of direct current at from 2 volts to 120 volts, and a large battery set are provided. All the main passages have false ceilings, which, in conjunction with the hollow interior walls, provide for the arrangement of adequate service facilities, including steam, compressed air, vacuum, constant-pressure water, alternating and direct current, gas and distilled water.

SIR GEORGE BEILBY MEMORIAL FUND.—As a mark of appreciation for distinguished work, awards are made to British investigators in science from the interest derived from the invested capital of the Sir George Beilby Memorial Fund. The awards are made at intervals determined by the administrators of the Fund, namely, the Presidents, honorary treasurers and secretaries of the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals. Preference is given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering and metallurgy, and awards are made, not on the result of any competition, but in recognition of continuous work of exceptional merit, bearing evidence of distinct advancement in science and practice. In general, awards are not applicable to workers of established repute, but are granted as an encouragement to younger men who have done original independent work of exceptional merit over a period of years. The administrators of the Fund inform us that they will be glad to have their attention drawn to outstanding work of the nature indicated, not later than November 1, 1940. All communications should be addressed to the Convener, Sir George Beilby Memorial Fund, Institute of Chemistry, 30, Russell-square, Bloomsbury, London, W.C.1.

# THE PORT ARTHUR-ORANGE BRIDGE, TEXAS, U.S.A.

(*For Description, see Page* 121.)

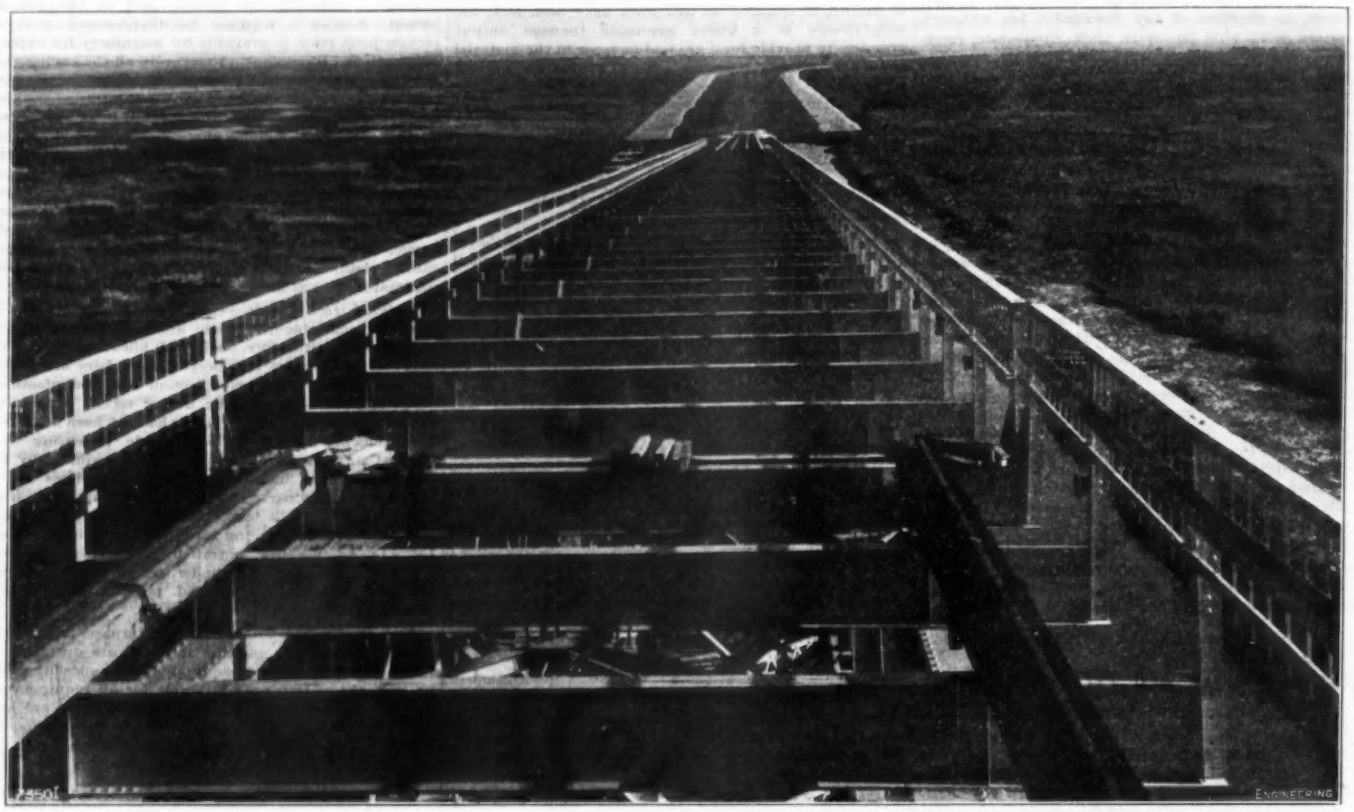

Fig. 57 Cross Girders and Crane Track.

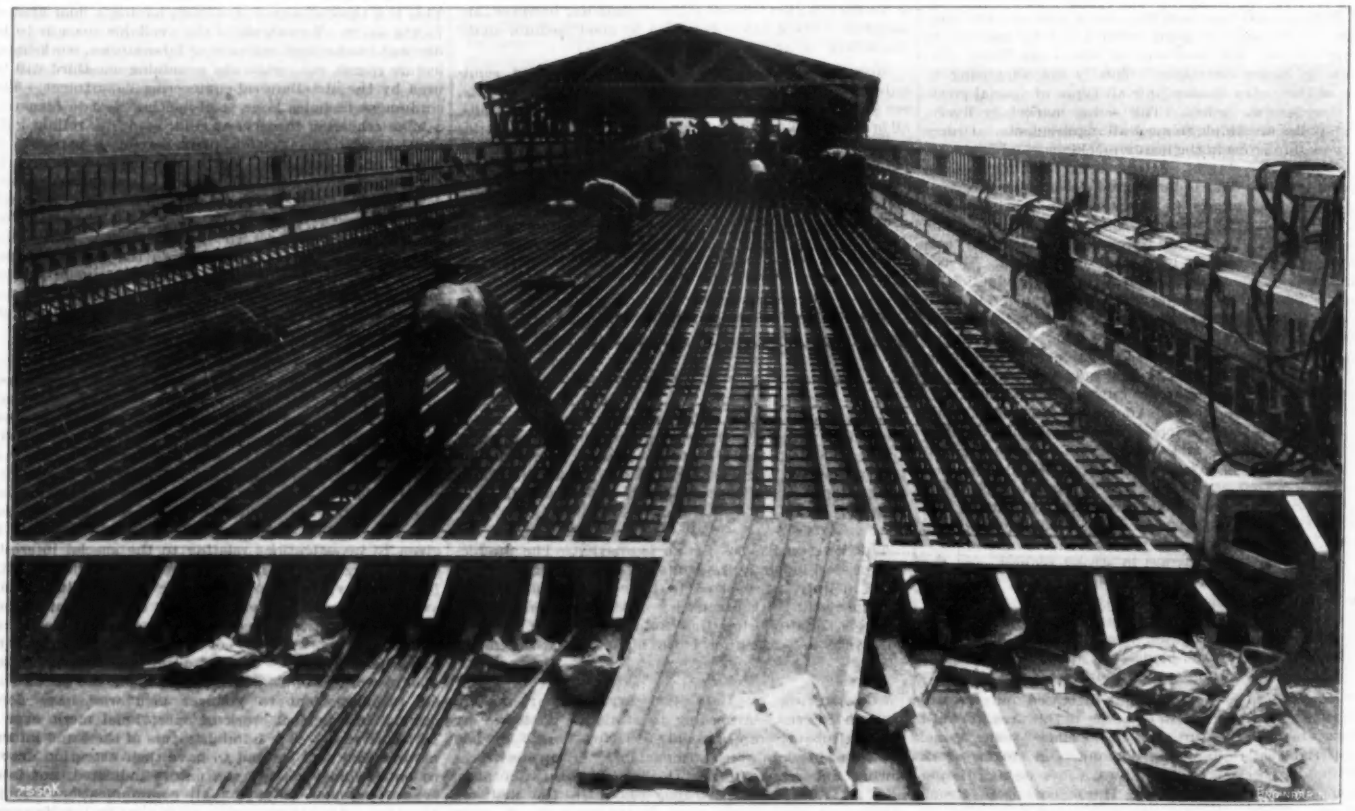

Fig. 58. Reinforcement for Road Slab.

# THE PORT ARTHUR-ORANGE BRIDGE O

(For Descriptio, see p

Fig. 44. Approach Spans and Falsework for Lattice Span.

Fig. 45. Inner Cantilever

Fig. 47. Closure of Top Chord of Suspended Span.

Fig. 48. Closure of Bottom Cho

# DGE OVER THE NECHES RIVER, TEXAS, U.S.A.

(For Description, see page 121.)

ER CANTILEVER ARM COMPLETED.

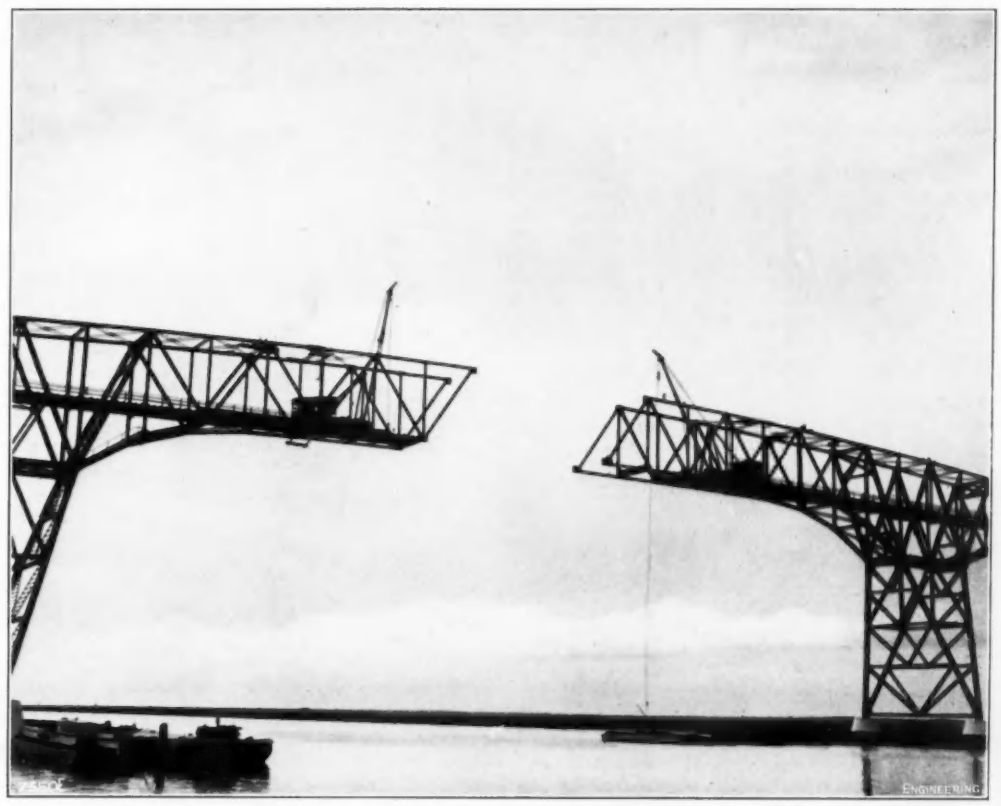


FIG. 46. CENTRE SUSPENDED SPAN PARTLY CONSTRUCTED.

BOTTOM CHORD OF SUSPENDED SPAN.

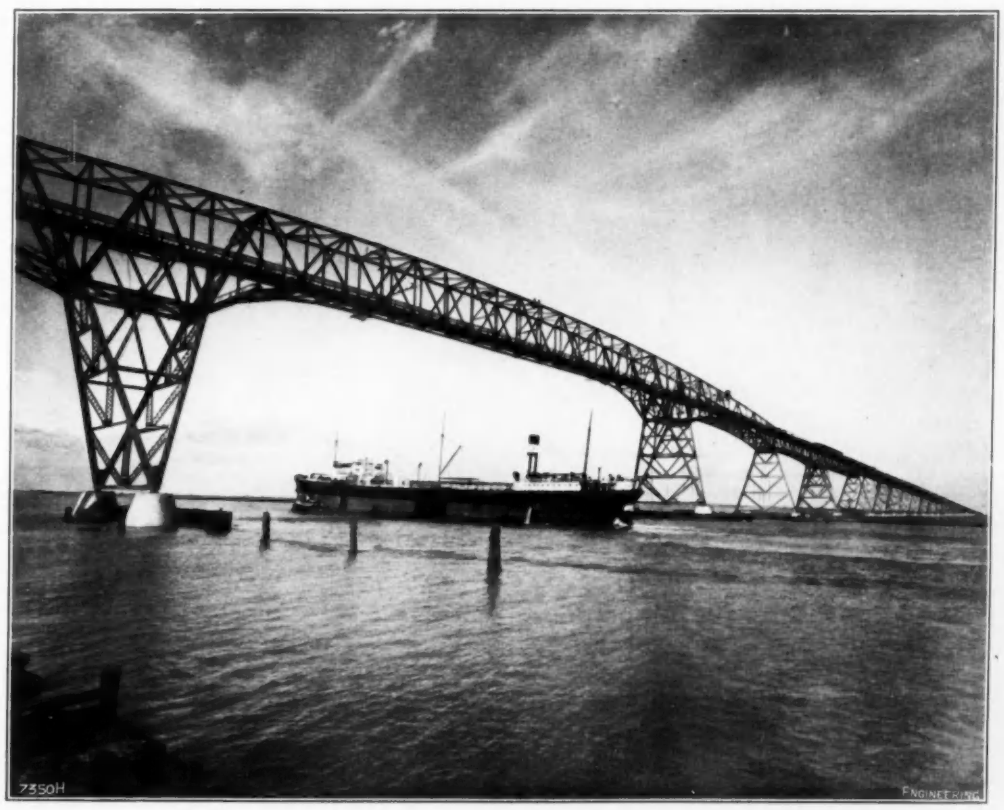


FIG. 49. COMPLETED RIVER CROSSING.

UNIV. OF MICH.

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*One Two-Page Plate.—THE PORT ARTHUR-ORANGE BRIDGE OVER THE NECHES RIVER, TEXAS, U.S.A.*



# ENGINEERING

*FRIDAY, AUGUST* 16, 1940.

VOL. 150. No. 3892.


## THE GOVERNMENT AND BRITISH SHIPPING.

LONG before the actual outbreak of war, it was evident that some form of Government control of virtually all British shipping would be essential from the outset of hostilities, and could not safely be postponed so long as it was in the last war. Regarding that lesson of 1914-18, there was no real doubt, especially in the light of the unsatisfactory position of the British shipping industry relatively to those of the various nations which had made a practice of heavily subsidising their mercantile marines, and of the probability that there would not be as good a reserve of tonnage in the fleets of neutral countries as was the case 26 years ago. In the main, these arguments were sound, although their practical fulfilment has taken courses that hardly could have been foreseen, as the result of Germany's extremely rapid subjugation of the European coast line from the Arctic to the Spanish frontier. The American Neutrality Act, and the consequent withdrawal of the considerable volume of United States shipping from European waters, was a development that certainly was not expected ; but, equally, the prophets never contemplated that so many millions of tons of shipping, belonging to what are now enemy-occupied territories, would be forced by circumstances to become, for all practical purposes, part of the British mercantile marine. As is well known, the net result has been that British shipping resources are now materially better than they were a year ago, quite apart from the new tonnage that has been completed for service, and in spite of a war loss of more than a million tons.

The sequence of events, so far as British ships were concerned, was that certain ships were requisitioned immediately for urgent naval and military needs, among them many well-known liners, some of which have since figured in official communiques. A few weeks later—in October of last year—a number of cargo vessels were requisitioned for the importation of iron ore ; and in December, the power to requisition was again invoked, to provide tonnage for grain imports. Finally, on January 4, 1940, the Minister of Shipping announced the intention of the Government to extend this policy, as from February 1, to all vessels on the United Kingdom or colonial register which were engaged in the deep-sea liner and tramp trades. Coasting vessels in general have not been requisitioned, apart from those required for specific purposes, and, indeed, they have found some difficulty in obtaining sufficient employment ; though it appears, from the published reports and photographs of recent air attacks on certain coastwise convoys, that a wider use is now being made of them, in pursuance of the policy indicated in the House of Commons.

The terms on which payment should be made for the requisitioned tonnage have been the subject of prolonged negotiations between the Ministry of Shipping, the Chamber of Shipping of the United Kingdom, and the Liverpool Steam Ship Owners' Association ; and, although payments were being made on account, some concern has been expressed from time to time, at general meetings of shipping companies, at the apparent delay in reaching decisions on these rates and in agreeing the conditions affecting Government liability for damage or loss arising from war risks. These conditions of employment and rates of hire have now been presented to Parliament,* and may be briefly outlined.

The basis on which the terms have been framed has been that the rates of hire should cover "a proper allowance for running expenses, a proper provision for current depreciation, and a reasonable return upon capital" ; but the Government "were unable to agree that it would be proper to include in these rates . . . any allowance towards making good past arrears of depreciation (apart from the allowance for accruing depreciation) or towards building up provision for replacement in the future." At the same time, it was recognised that the British mercantile marine must be maintained in adequate strength, and "in a position of full competitive efficiency" ; and an assurance is given that this necessity, which led to the schemes of assistance embodied in the British Shipping (Assistance) Bill of 1939, will be kept in mind.

It is hardly necessary to record the details of the three forms of charter-party which have been agreed, each of which is based upon former practice, with sundry modifications to take account of developments since the previous war. The three forms are designed to cover (*a*) chartering on a "bare boat" basis, the requisitioning authority assuming entire responsibility for manning, upkeep, and all other functions of ownership, including liability for war and marine risks ; (*b*) the chartering of vessels, primarily passenger liners, to be employed as troop transports or hospital ships, maintained, manned, insured against marine risks, and provided with stores by the original owners, but insured against war risks by the requisitioning authority, which also meets charges for fuel and dues ; and (*c*) chartering of cargo vessels and ships to carry military stores, generally on similar terms to (*b*). The last-mentioned charter-party also applies to liners requisitioned under the scheme which became operative on February 1, 1940 ; and there is a particular form of the same charter-party applicable to tankers. In each case the charter provides that the ships (unless lost) are to be redelivered "in the same good order as they were delivered, fair wear and tear and depreciation excepted." Charter-parties (*b*) and (*c*) include an "inefficiency clause," providing that the hire shall be suspended or terminated if, for various reasons, including breakdown of machinery, the vessel is unable to proceed upon her allotted service within stated periods.

Provision for the grant of compensation to owners of requisitioned ships is made in the Compensation (Defence) Act, 1939, which also contemplated the establishment of general rates of hire, by agreement, for whole classes of ships. Working on these lines, therefore, the Minister of Shipping discussed with the Chamber of Shipping and the Liverpool Steam Ship Owners' Association the establishment of three scales, for liners, tramp ships and tankers, respectively. In the case of

* *Memorandum on War-Time Financial Arrangements between His Majesty's Government and British Shipowners.* London : H.M. Stationery Office. [Price 4*d.* net.]

liners, the allowances are 5 per cent. for interest on capital and 5 per cent. for depreciation, to which total is added, in the case of vessels operating under either of the charter-parties designated (*b*) and (*c*), above, a "basic rate" representing the average cost, for the class of ship concerned, of the various items of expenditure to be met by the owners, such as wages, victualling, stores, repairs, etc. The basic rates for passenger liners of 5,000 tons gross or more depend partly on speed and partly on the composition of the crew (to allow for vessels carrying lascars or similar crews); and certain additional payments are authorised to meet special circumstances, such as maintaining the classification of old ships which, but for the war, would have been withdrawn from service. In the case of tramps, the allowances for interest and depreciation are similar, but the basic rate is not separately worked out for each vessel; a "basic vessel" of fair average value is taken as a criterion. For tramp ships below 8,000 tons deadweight the rate of hire varies inversely with tonnage, and is increased slightly for periods of hire after March 1, 1940, when certain increases of wages to crews came into operation. It is interesting to note that motor vessels receive from 10 per cent. to 16 per cent. more than steam vessels of equal tonnage.

Included in the memorandum are brief summaries of the position regarding the shipbuilding loans and shipbuilding grants which formed important parts of the proposals embodied in the British Shipping (Assistance) Bill. In October last, the President of the Board of Trade announced that, although the Government had decided to allow the Bill to lapse, applications would be considered for loans towards the cost of vessels of the types to which the original scheme applied and in respect of which definite orders had been placed. Applications were received, it is stated, in respect of 69 ships, representing a gross tonnage of 303,855 and an estimated total cost exceeding 8,000,000*l*. Some were withdrawn later, and others were adjudged ineligible, but approval was given for loans totalling 4,817,005*l*., covering the construction of 50 tramp ships and five cargo liners. In addition to the system of loans, it was proposed to make grants, to a total not exceeding 2,500,000*l*., towards the construction of new cargo vessels. It is estimated, according to the Memorandum, that about 100 vessels, which have been or are being built, will rank for these grants.

While it is easy to appreciate the reasons which caused the Government to restrict the allowance for depreciation on requisitioned ships to that representing current depreciation only—the principal argument being that neither accumulated arrears of pre-war depreciation nor the building up of reserves towards eventual replacement can be properly regarded as a war charge upon the community as a whole—it must be admitted that the future prospects for British shipping, when hostilities cease, are by no means clear. Although the orientation of the various European nations directly involved is, perhaps, more clear-cut in the present conflict than in the last, the effect of the present war upon world shipping trade probably represents a more serious upheaval, and one likely to prove more difficult of redress when the time comes to restore normal conditions of trading. It may be taken as certain that British shipping will not have to face quite so unequal a competition in some fields as it had to do after the last war, as most of the potential competitors have suffered an even more severe destruction of assets and goodwill than is represented by the diversion of so many British ships to purely war purposes: but shipping, like any other commercial activity, cannot be carried on indefinitely at a loss, or maintained on an efficient basis if replacements, inevitably at a greatly enhanced cost, cannot be met out of revenue. Such figures as the total of 1,325,000*l*., which, as stated in the report of the Royal Mail Lines, Limited, that company has reserved for fleet replacement, may look imposing enough to the uninstructed public; but such a sum will not go far towards the replacement of a fleet, and it may well be that one effect of the war will be a tendency towards smaller and slower vessels than have become customary in particular services.

## LOST MOTION.

While it is always important that muscular energy should not be wasted, and time lost, by workpeople having to make unnecessary movements when operating machine tools, it is doubly so under present conditions. Apart from the fact that the time and energy of all workers are now too valuable to be dissipated, the ingress of large volumes of new labour to the shops accentuates the necessity for arranging industrial operations in such a way that they can be carried out with the minimum of fatigue. Many of the new workers are likely to have had little experience in machine operation and may have a natural tendency, based on unfamiliarity, to waste effort in useless movements. It is a commonplace of writers on production methods that shop layout is a fundamental factor in economic production, and, in practice, much attention is paid to the matter. In modern factories the location of the stores, the disposition of the machines performing the various operations and the position of the inspection department are all related to a flow of work designed to eliminate unnecessary movement either of materials or personnel.

Apart from this question of saving time and effort by arranging for the straightforward progress of the manufactured product through the shops, the energy of the workpeople may be conserved by arranging machine controls in such a way that useless movements are eliminated and necessary movements are made as simple as possible. This, again, is a subject to which much attention has been paid. It is hardly possible to get a description of a machine tool from its makers, in which the convenience of the controls is not stressed as one of the valuable features of the design. In spite of this, however, and the fact that no machine-tool designer would be likely to admit that convenience of control was not one of the fundamental considerations which he had continuously in mind, it still appears that, even to-day, the best arrangement is not always arrived at. In a paper read before the American Society of Mechanical Engineers last December, Messrs. O. W. Habel and G. G. Kearful were able to instance a number of machine tools and other shop plant in which, by small modifications of the controls, they had been able to relieve the operator from fatigue and improve his output. It is somewhat surprising that this record of experience should come from the United States in which, following the work of Gilbreth, considerably more attention has been paid to questions of motion study than has been the case in other countries. The authors, who are connected with the General Motors Corporation, perhaps explain the matter when they say that they are "only users of machinery." The fact that the man who designs a machine is generally not the man who uses it, frequently results in convenience in operation being sacrificed to convenience in layout. One has often heard the suggestion that the best training the designers of some motor cars could undergo would be a few months devoted to the maintenance of their own products.

A singularly simple and yet perhaps the most striking example quoted in the paper, which is entitled Machine Design and Motion Economy, is that of a dynamic balancing machine. This consists of a horizontal table some 12 ft. long, above which the shaft or other part to be balanced is carried between suitable fittings at each end of the table. Behind each fitting there is an indicating chart provided with a hood on its upper side. As originally manufactured, the chart heads were arranged parallel to each other, the charts facing straight forward, with the result that the operator had to walk about 8 ft., from one end of the machine to the other to check the balance of each part being tested. The authors modified the machine by inclining the heads so that the operator could see both charts from his normal position, opposite the centre of the machine, without having to move. There would appear to be no excuse for the original design of this machine, but in the case of two furnaces equipped with chain conveyors it might be argued that the modification introduced by the authors complicated the foundations and made the appliances of less universal application. There was a large counterweight at the front of the furnaces, used to balance the fire door. Behind this was a table with an opening at its far side through which the conveyor was loaded. The operator had to reach over the table and counterweight in order to feed parts on to the conveyor. By placing the counterweight below the floor, so that it did not obstruct the front of the machine, and by increasing the size of the opening in the table, bringing its edge nearer to the front, the loading operation was so facilitated that the two furnaces could be operated by one man. Two had previously been required.

The other examples quoted by the authors of the paper are more directly concerned with machine controls as ordinarily understood. For instance, an air-operated lathe tailstock had separate control levers for the air valve and the clamp. By fitting a fork to the air valve, which was operated by a cam on the locking lever, the two operations were controlled by a single movement, reducing the lost time between the machining cycles. In another case, the fitting of a pedal in place of a hand lever on a multiple sensitive drill engaged on a countersinking operation resulted in a 47 per cent. increase in production. The success achieved in this case was probably due to the type of work on which the machine was engaged. By no means all of the operations carried out on sensitive drilling machines are suitable for foot control. The next example, however, is in no way limited in application by the type of work being done. The authors say "one of the most common faults with machines as received from the builder is that they are equipped with small, hard-to-find starting buttons." They quote a case in which the operator had to "lean back, twist his body and 'eye-direct' his hand to the button each time the machine went through its cycle." This was remedied by fitting a palm button close to the loading station.

This question of the arrangement of machine controls in order to facilitate operation has another aspect. Levers and handwheels should be so placed that not only are the operator's movements made as small as possible, but those movements should also be made as easily as possible. Although this sounds obvious, it is not always acted up to and cases can be found in which a lever has to be pushed when muscular energy would be saved if it could be arranged to be pulled. In general terms, this will be admitted, but when the question of convenience in machine arrangement comes to be balanced against the relative merits of pushing or pulling in any particular case, it may not be easy to say how much should be sacrificed in other directions in the interests of pulling. Some quantitative investigations bearing on this matter have been made by Mr. C. A. Koepke and Mr. L. S. Whitson, of the University of Minnesota, and were described in a paper entitled "Power and Velocity Developed in Manual Work," which was presented at the Milwaukee meeting of the American Society of Mechanical Engineers last June. The authors' experiments were made with six men of various physical builds, who were required to accelerate weights of 6, 9, 12, 15, 18 and 21 lb. with one hand. The weights were placed on a table in front of the man and he had to move them from left to right, right to left, forward and backward, and so on. The maximum velocity reached in each type of motion was measured. The experiments established, on a quantitative basis, that the greatest power is developed with a pulling motion towards the body, the next greatest being with a long backhand sweep from left to right. An interesting result found was that the handling of small light-weight parts may require as great an expenditure of energy as the handling of heavier pieces, owing to the power required to accelerate the hand and arm being greater owing to the higher velocities and rate of acceleration with the lighter objects. These experiments as carried out were more directly applicable to repetition assembling and packing operations than to machine-tool controls, but with modification and extension they might furnish useful information on the best positions and arrangements for starting or other levers.

# NOTES.

## THE WAR IN THE AIR.

THERE is good reason to believe that since the beginning of the war, up to and including Monday, August 12, our aircraft and ground defences have accounted for more than 3,000 German aircraft. This figure does not include aircraft bombed on the ground or the large number of machines which were damaged so severely in aerial combat that they probably did not reach home; nor does it include the Italian machines which have been brought down during the last few weeks, though the number of the latter is quite considerable. This very satisfactory total is the fruit of months of unceasing skill and vigilance on the part both of the Royal Air Force and the anti-aircraft organisation at home and abroad. It is sometimes difficult to recall that we have been at war for nearly a year, and that during the whole of that time there has been no relaxation of their watchfulness for a moment, day or night. Between June 18 and August 13, Germany has lost 505 aircraft and, since Tuesday, August 6, when the air attacks on this country became intensified, no less than 269 machines have been brought down, while on three successive days the number destroyed has exceeded 60. These attacks, it may be emphasised, were no mere reconnaissances, but were demonstrations in great force against places of such military importance as Portsmouth, Portland and Dover. It is therefore significant not only of the present, but of what may come, that our own losses only amounted to 71, a proportion of one to four. This is so great a disparity that the most pessimistic must have great hopes of our superiority, even though the attacks increase in vigour, as well they may. There is, indeed, good evidence to show that our machines are fulfilling the hopes of their designers and that their crews are not abating a jot, either of their skill or their enterprise as the enemy's efforts become stronger. At the same time, there is some indication that the Germans, for their part, are employing more experienced pilots than formerly, though even these are not reluctant to seek a safe harbourage on English soil. This account of the latest phase of aerial warfare may be completed by recording that since September, 1939, up to Monday last, we had lost 709 machines, 401 of which were brought down over France, and only 109 in the numerous flights that have been made over Germany. Still more important is that Germany has been deprived of an equal number of pilots, who will be difficult to replace, and that before long our constructional efforts should ensure us equality and ascendancy in the production of machines.

## THE REGISTRATION OF ENGINEERING LABOUR.

This has been described as an engineers' war. If the implication of the term is, not that engineers made the war, but that the whole of their assistance will be necessary to win it, then it may be accepted. To turn over all engineering activity from the multifarious occupations of peace to those of war is, however, a task of enormous magnitude, and it is a matter for neither surprise nor criticism that it has not been completed in a period which is now but a few weeks short of a year. The first concerted effort to enumerate engineering skill and knowledge was probably the formation of registers of their members by the great engineering institutions. These have now been merged in the Central Register, and similar registers of chemists and physicists have been compiled. The men listed in this way represent, in general, the directing force, to take full advantage of which corresponding registers of skilled labour are necessary. Up to the present, the necessary increase in the skilled labour force has been recruited mainly on a voluntary basis, but as this has not produced numbers sufficient to fill the thousands of vacancies which the armaments programme has created and is continually adding to, the Minister of Labour has now issued an order requiring skilled men to add their names to a register which, when complete, will provide a fairly complete picture of the spare skilled labour force of the country. The register is intended to cover men in engineering and allied industries who are not employed on Government work; men of similar skill employed on maintenance and repair on non-Government work; and men who, within the last twelve years, have been engaged on skilled engineering work for at least twelve months, and have since passed into other occupations. Men employed on Government work, shipbuilding and ship-repairing, iron and steel, or non-ferrous metal manufacture, or with the main-line railway companies and the London Passenger Transport Board are not required to register. The order applies to men over the age of 21 and who have not attained the age of 65. In order that workpeople shall understand exactly what is covered by "engineering and allied industries," and shall, therefore, know whether they are required to register or not, and schedule of occupations has been published, men engaged in which are covered by the order. The schedule is as follows:—Brass, bronze, aluminium and other non-ferrous metals, finisher, fitter; coppersmith; core maker; die caster; draughtsman (engineering, jig or tool); electrician, including wireman; fitter, assembler, erector, marker-out (engineering and kindred trades, including electrical). Forgeman, including power hammer smith, forge hammerman, forge pressman, hot stamper, hot drop stamper, drop-hammer smith, drop forger; gunsmith, inspector, tester, viewer, examiner (engineering and kindred trades, including electrical). Instrument maker or assembler—all kinds, including scientific, optical, surgical, dental, electrical, wireless, watch and clock, telegraph, telephone; lead-burner (chemical plumber); lens worker, prism worker; machinist, including driller (boiler, constructional). Metal annealer, hardener, temperer; metal machinist, including turret-lathe operator, capstan lathe operator, miller, borer, grinder, planer, shaper, slotter, driller; millwright, maintenance man (metal); moulder (iron, steel, brass or other non-ferrous metals); power press operator (metal); sheet iron worker, sheet metal worker, including tinsmith. Toolsmith; toolmaker, press toolmaker, die sinker (cutter), jig or gauge maker; toolsetter (machine or press tools); turner (metal); welder (gas or electrical). Registration will take place during the five days, August 19 to 23, inclusive.

## ELECTRICAL INSTALLATIONS IN WAR TIME.

In normal times, Government departments buy the materials they require to rigid specifications, and naturally demand that they shall be of high, if not of the highest, quality. Such a policy implies a certain degree of permanency, which does not exist in war; and, therefore, there has been some criticism of its continuance, especially as such inflexible interpretations of the letter of peace-time specifications tend to hold up output. The electrical industry, in particular, has pointed out that it is uneconomical and wasteful of time to make the wiring installations of temporary buildings comply with the highest standards when something cheaper would do the job equally well. Their criticism is well-founded, and, we fear, of more general application than is commonly supposed; so that we are glad to learn that the Works and Building Priority Committee of the Production Council are revising the specifications for electric light and power installations. It has now been decided that there shall be different types of contract for permanent and "other" work, respectively. The first category covers work which requires an exceptionally high degree of safety and as, at the present time, it forms but a small proportion of the whole, the advantages of using low-grade materials would not compensate for other drawbacks. Only a few substitutions and minor modifications in layout will be made to effect economies. On the other hand, considerable savings will be possible on installations in the second category by using a cleat wiring system instead of the more favoured steel conduit. Plastic materials, too, are to be employed as much as possible to replace metal, and wood-cased distribution boards will be substituted for iron. If it be thought that these are retrograde steps, the reply must be that we are at war and that, provided the workmanship is adequate, such installations as those proposed are quite suitable for temporary buildings. On a smaller scale, it is interesting to note that the Ministry of Health is working in the same direction and, owing to the pressing demands for copper, zinc and brass for munitions production, has issued an appeal for economy in the use of these metals for other purposes. In particular, it is suggested that local authorities and statutory undertakings should no longer require that water fittings shall comply with either the J.C.S.W.R. or the M.O.H. standards, but should adopt the second, or lower, standard for use in buildings of a permanent character, and use any suitable stock pattern for temporary buildings.

## MACHINE TOOLS IN GENERATING STATIONS.

The recent Census of Machine Tools has probably brought to light the existence of a number of useful machines in more or less unexpected places. Garages, repair shops, either owned by village handymen or by non-engineering factories, and builders' yards, are cases that come at once to mind, while others are generating stations and gas and chemical works, where a machine shop is a useful, if subsidiary, adjunct to the main business. Though individually such sources of production may not be large, in the aggregate they are considerable and as their "load factor" is inevitably low they could well be placed under requisition for munition purposes at the present time. We are, therefore, glad to learn that the Ministry of Supply has recently been in consultations with the Electricity Commissioners concerning the extent to which machine tools in the workshops of electricity undertakings might be made available for production work on munitions. While the Ministry were informed that the number of such machines was relatively small, it was agreed that a limited use might be made of them at night time and at week ends in connection with general production work, provided sufficient labour was made available; and the Commissioners, therefore, have been asked to obtain the information necessary to assist the Ministry in coming to a decision in this matter. Electricity undertakings, accordingly, are being asked to give the Commissioners at the earliest possible date the number and detailed description of the machines installed in their repair shops, as well as the hours between which any of the machines would be available for munition production work. They are also asked to state the amount of labour available in the undertaking to man the machines during the hours named, and the amount of labour that would be required from outside sources if the machines are available.

## THE TAX ON KNOWLEDGE.

In the House of Commons, on August 13, the Chancellor of the Exchequer announced that he had decided to exempt newspapers and books from the Purchase Tax. In taking this course, Sir Kingsley Wood has wisely bowed to the protests of authors, publishers and booksellers, who argued not merely for self-interested reasons, that this impost would, by increasing the price, place a restriction on the dissemination of knowledge, and, as far as the newspapers were concerned, would tend to keep the public in a state of ignorance which, as events in France have shown, might be highly dangerous to the safety of the country. As one of G. B. Shaw's characters remarked, however, the right things are sometimes done for the wrong motives, and it is highly probable that a weighty reason for the concession is that it has been found that the yield of the tax would not have compensated for its obvious disadvantages. In a letter to *The Times* of the same date, Mr. Geoffrey Faber, President of the Publishers' Association, pointed out that the Treasury had estimated that during a full year the yield would be between 1,000,000*l.* and 1,250,000*l.* This estimate, he showed, appeared to be based on a turnover of 7,000,000*l.*, while actually, owing to the decline that had set in since the beginning of the war, the figure would be much less. Indeed, though nobody could estimate the yield, it was probable that it would not be as much as 500,000*l.* The question, therefore, is whether it is desirable to dislocate a useful trade for the sake of so small a sum, and the answer that has now wisely been given is that it is not. The nation is to be congratulated on this successful outcome.

# CREEP UNDER COMBINED TENSION AND TORSION.

## Part I.—The Behaviour of a 0·17 Per Cent. Carbon Steel at 455 deg. C.

By H. J. Tapsell, A.C.G.I., A.M.I.Mech.E., and A. E. Johnson, M.Sc.

(*Continued from page* 105.)

### Appendix I.

By A. E. Johnson, M.Sc.

The method of computing from the measured axial and circumferential creep rates, the corresponding rates in the three directions of principal stress for a thin-walled tubular specimen subjected to combined stresses will now be given. The theory is essentially that of Taylor and Quinney,* adapted to suit creep conditions. The theory is as follows. Consider the tube in Fig. 20. Let $t$ be the axial stress, and $s$ the shear stress due to torque. Let $e$ represent axial strain, and $g$ torsional strain. Then the applied stresses, and resulting strains in the directions $x$, $y$, and $z$, using the normal nomenclature are :—

$$\left.\begin{array}{lll} X\,x = t, & Y\,y = 0, & Z\,z = 0 \\ X\,y = s, & Y\,z = 0, & Z\,x = 0 \end{array}\right\} \text{for stresses.}$$

$$\left.\begin{array}{ll} e\,x\,x = e, & e\,y\,y = -\tfrac{1}{2}e - f, \quad e\,z\,z = -\tfrac{1}{2}e + f \\ e\,x\,y = g, & e\,y\,z = 0, \qquad e\,z\,x = 0 \end{array}\right\} \text{for strains}$$

where $f$ is proportional to the change of internal volume of the tube, and

$$= -\tfrac{1}{2}\left\{\frac{\text{change of internal volume}}{\text{internal volume}}\right\}$$

Stress and strain quadrics may be expressed as follows :—

Stress (1) $t\,x^2 + 2s\,x\,y = \text{constant}.$

Strain (2) $e\,x^2 - (\tfrac{1}{2}e + f)y^2 - (\tfrac{1}{2}e - f)z^2 + g\,x\,y = \text{constant}.$

Substitute in

$$\left.\begin{array}{l} (1)\ x = x'\cos\theta - y'\sin\theta \\ \quad\ y = x'\sin\theta + y'\cos\theta \end{array}\right\}$$

and in

$$\left.\begin{array}{l} (2)\ x = x'\cos\phi - y'\sin\phi \\ \quad\ y = x'\sin\phi + y'\cos\phi \end{array}\right\}$$

and equations giving the directions of the principal axes of stress and strain are obtained.

(1) becomes

$$x'^2\left\{t\cos^2\theta + 2s\cos\theta\sin\theta\right\} + y'^2\left\{t\sin^2\theta - 2s\cos\theta\sin\theta\right\} + 2x'y'\left\{(-t\cos\theta\sin\theta + s(\cos^2\theta - \sin^2\theta)\right\} = \text{constant}.$$

and (2) becomes

$$x'^2\left\{e\cos^2\phi - (\tfrac{1}{2}e + f)\sin^2\phi + g\sin\phi\cos\phi\right\} + y'^2\left\{e\sin^2\phi - (\tfrac{1}{2}e + f)\cos^2\phi - g\sin\phi\cos\phi\right\} + x'y'\left\{-\left(\frac{3e}{2} + f\right)\sin 2\phi + g\cos 2\phi\right\} - \left\{\tfrac{1}{2}e - f\right\}z^2 = \text{constant}.$$

To refer these quadrics to their principal axes, the coefficient of $x'\,y'$ is equated to zero in each case. Then

$$(a)\ \tan 2\theta = \frac{2s}{t} \text{ from (1)}$$

and

$$(b)\ \tan 2\phi = \left(\frac{g}{\frac{3e}{2} + f}\right) \text{ from (2)}$$

Then

$$\frac{2s}{t} = \left(\frac{g}{\frac{3e}{2} + f}\right)$$

providing $\tan 2\theta = \tan 2\phi$, *i.e.*, providing the principal axes of stress and strain coincide. Taylor and Quinney have established this as a fact for several materials. Dr. R. W. Bailey also obtained evidence of the coincidence of these axes in the case of a carbon steel. In the absence of evidence to the contrary it is assumed to be so in the present case. We thus have

$$(c)\ f = \frac{g\,t}{2s} - \frac{3e}{2}.$$

Substitution from (*a*), (*b*) and (*c*) in the coefficients of $x'^2$ and $y'^2$ of (1) and (2) gives us the principal stresses and strains as follows :—

*Principal Stresses.*—

$$p_1 = t\cos^2\theta + 2s\cos\theta\sin\theta$$
$$= \frac{t^2}{2\sqrt{t^2 + 4s^2}} + \frac{t}{2} + \frac{2s^2}{\sqrt{t^2 + 4s^2}}$$
$$= \frac{t}{2} + \frac{1}{2}\sqrt{t^2 + 4s^2}.$$

$$p_2 = t\sin^2\theta - 2s\sin\theta\cos\theta$$
$$= \frac{-t^2}{2\sqrt{t^2 + 4s^2}} + \frac{t}{2} - \frac{2s^2}{\sqrt{t^2 + 4s^2}}$$
$$= \frac{t}{2} - \frac{1}{2}\sqrt{t^2 + 4s^2}.$$

$$p_3 = 0.$$

*Principal Strains.*—

$$e_1 = e\cos^2\phi - (\tfrac{1}{2}e + f)\sin^2\phi + g\sin\phi\cos\phi$$
$$= e\left(\frac{t}{2\sqrt{t^2 + 4s^2}} + \frac{1}{2}\right) - \left(\frac{gt}{2s} - e\right)\left(\frac{1}{2} - \frac{t}{2\sqrt{t^2 + 4s^2}}\right) + \frac{g\,s}{\sqrt{t^2 + 4s^2}},$$

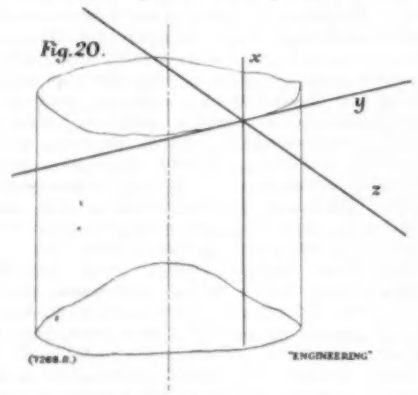



Fig. 20.

which on simplification becomes

$$= e + \frac{g}{2}\left(\sqrt{\left(\frac{t}{2s}\right)^2 + 1} - \frac{t}{2s}\right).$$

$$e_2 = e\sin^2\phi - (\tfrac{1}{2}e + f)\cos^2\phi - g\cos\phi\sin\phi$$
$$= e\left(\frac{1}{2} - \frac{t}{2\sqrt{t^2 + 4s^2}}\right) - \left(\frac{g\,t}{2s} + \frac{e}{2} - \frac{3e}{2}\right)\left(\frac{t}{2\sqrt{t^2 + 4s^2}} + \frac{1}{2}\right) - \frac{g\,s}{\sqrt{t^2 + 4s^2}},$$

which on simplification becomes

$$= e - \frac{g}{2}\left(\frac{t}{2s} + \sqrt{\left(\frac{t}{2s}\right)^2 + 1}\right)$$

$$e_3 = -\tfrac{1}{2}e + f = -\tfrac{1}{2}e - \frac{3e}{2} + \frac{g\,t}{2s}$$
$$= \frac{g\,t}{2s} - 2e.$$

Introducing the time element, the above expressions for $e_1$, $e_2$, and $e_3$ give the creep rates in the three directions in terms of the axial, and torsional creep rates, and the creep rate in direction (2) indicates whether or not creep takes place in planes other than those of maximum shear.

Thus, if

$$\frac{d\,e}{d\,t} = C_a, \text{ and } \frac{d\,g}{d\,t} = C_c,$$

we have the following relations

$$(A)\ C_1 = \frac{d\,e_1}{d\,t} = C_a + \frac{C_c}{2}\left(\sqrt{\left(\frac{t}{2s}\right)^2 + 1} - \frac{t}{2s}\right)$$

$$(B)\ C_2 = \frac{d\,e_2}{d\,t} = C_a - \frac{C_c}{2}\left(\frac{t}{2s} + \sqrt{\left(\frac{t}{2s}\right)^2 + 1}\right)$$

$$(C)\ C_3 = \frac{d\,e_3}{d\,t} = C_c\,\frac{t}{2s} - 2\,C_a.$$

Similar equations were derived by R. W. Bailey using an entirely different method of approach. This agreement would seem to confirm the accuracy of the above equations.

It should be noted that in the case of pure tension the equations for $C_2$ and $C_3$ give indeterminate results. In this case, $C_2$ and $C_3$ are computed from the measured $C_1$ on the assumption of constant isotropy and density, and that

$$C_2 = C_3 = -\tfrac{1}{2}C_1$$

(*To be continued.*)

* See "The Plastic Deformation of Metals," *Phil. Trans. Royal Society*, vol. 230, page 323 (1932).

# RAPID DISCHARGE OF GAS FROM A VESSEL INTO THE ATMOSPHERE.

By E. Giffen, Ph.D., M.I.Mech.E.

Part I. *Based on Consideration of Wave Action in the Vessel.*—The problem considered in the following analysis is the rate at which the internal pressure decreases when the contents of a vessel are allowed to discharge into the atmosphere through a rapidly-opened port. This has an important bearing upon the exhaust process in internal-combustion engines, particularly in the case of two-stroke cycle engines operating at high speeds. In such engines, the time available for the discharge of the exhaust gas is very short and requires the rapid opening of the exhaust port or valve. The rate of opening is controlled either by the movement of the piston or by a cam driven from the engine crankshaft, but in either case the rate of variation of the port area is accurately known. Further, the movement of the piston is comparatively small during the period of pressure release, so that the cylinder may be regarded as being of constant volume during this time ; it will be seen later, however, from the method of treatment adopted, that any known rate of variation of the volume of the vessel would present no difficulty. While the conditions of the problem discussed resemble, to some extent, those of the exhaust period in an internal-combustion engine, the two problems are not exactly similar, since in the case of the engine a pipe is usually interposed between the cylinder and the outlet to the atmosphere. The presence of the pipe has a quite definite effect upon the conditions inside the cylinder, due, firstly, to the resistance offered by the contents of the pipe to the discharging gas, and secondly, to the wave action set up in the pipe. For the present, however, this additional complication is avoided by directing attention to the basic problem of discharge directly into the atmosphere.

It is necessary at this point to consider the implications of the term "rapid" as applied either to the opening of the discharge port or to the discharge of the gas itself. The term is only a relative one, and involves the comparison of the rates at which the various changes occur with some condition which plays a controlling part in the discharge. This controlling condition is the speed with which any disturbance is transmitted through the contents of the vessel, *i.e.*, the speed of sound in the gas, and it has an important influence upon the phenomena occurring inside the vessel during the discharge process. When the orifice or port is small in relation to the size of the vessel, the rate of variation of the pressure inside the vessel is small compared with the rate at which the variations in pressure are transmitted through the gas, and the pressure may be assumed to be constant in all parts of the vessel. Under these conditions, also, the velocity with which the gas in the vessel approaches the discharge port is relatively small, and is usually neglected. If the size of the discharge port be increased, the rate of discharge, and the rate of variation of pressure inside the vessel, will also increase. A point will be reached when the rate of change of pressure near the discharge port is so great that an appreciable pressure difference will exist in different parts of the vessel, on account of the time required for the transmission of any pressure change from one part to another. There will, therefore, be a pressure gradient in the vessel, those points farthest removed from the port lagging most behind the pressure at the port. The rate of discharge, however, is determined, so far as the conditions inside the vessel are concerned, by the pressure and density close to the port, and by the velocity with which the gas approaches the port. This velocity of approach follows, of course, from the pressure variations throughout the vessel. It will be seen, therefore, that the conditions near the discharge port may vary considerably from those which follow from the assumption of a uniform pressure and zero velocity inside the vessel, and the calculated rate of discharge would be affected accordingly. The factors that

determine the extent of the pressure variations in the vessel are: firstly, the rate of change of the pressure near the port; and secondly, the time required for any change at the port to be transmitted throughout the vessel. The former depends upon the size of the discharge port in relation to that of the vessel, as well as upon the pressure difference on the two sides of the port; and the latter depends upon the distance from the port to the farthest point in the vessel, and also upon the speed of sound in the gas. When either of these factors produces such variations in the internal conditions that they have an appreciable effect upon the calculated rate of discharge, or lead to phenomena which would be absent with a uniform pressure in the vessel, the discharge may be said to be "rapid." In such cases it becomes necessary to consider the mechanism whereby the variations in pressure near the port are transmitted through the contents of the vessel.

*Wave Action in the Vessel.*—In a consideration of the propagation of these pressure waves, it is convenient to assume the vessel cylindrical in shape, with the discharge port at one end, so that any disturbance at the port is transmitted as a plane wave along the axis of the cylinder. The properties of such waves have been discussed by Earnshaw (1860)* and by Rayleigh (1910)†, and for the present purpose the most important results may be stated briefly as follows: If a plane wave of finite amplitude passes through a column of gas originally at rest and having a density $\rho_0$, then at any point where the density is $\rho_1$ the gas will have a velocity $v_1$, in the direction of the discharge port, given, for adiabatic conditions, by the relation:—

$$\left(\frac{\rho_1}{\rho_0}\right)^{\frac{\gamma-1}{2}} = 1 \pm \frac{\gamma-1}{2}\frac{v_1}{c_0}, \quad . \quad . \quad (1)$$

where $\gamma$ is the adiabatic index, and $c_0$ the speed of sound in the gas in the initial condition. The positive and negative signs apply to positive and negative waves, respectively, *i.e.*, to waves in which the direction of propagation of the wave is in the same direction as, or in the opposite direction to, the movement of the gas. The speed of propagation varies with the density, *i.e.*, with the gas velocity, and is given by the expression $c_0 \pm \frac{\gamma+1}{2} \cdot v_1$. The positive and negative signs again refer to positive and negative waves.

If pressure be substituted for density in (1), the equation becomes, for adiabatic conditions,

$$\left(\frac{p_1}{p_0}\right)^{\frac{\gamma-1}{2\gamma}} = 1 \pm \frac{\gamma-1}{2}\cdot\frac{v_1}{c_0}, \quad . \quad . \quad (2)$$

which is a more convenient form for the present work. In this expression, $p_1$ is the absolute pressure in the vessel at the point where the gas has the velocity $v_1$, and $p_0$ the absolute pressure at the point where the gas is at rest, before disturbance by the pressure wave.

With these results it is now possible to follow the various changes in pressure and velocity inside a cylindrical vessel when discharge takes place through a port in one end. The gas is initially at rest and at a pressure denoted by $p_0$. It is assumed that the opening of the port occupies a very short but finite interval of time, and that the area of the port then remains constant. As soon as this constant area has been reached the pressure inside the vessel, near the port, will have fallen to $p_1$, and this drop in pressure is propagated as a negative wave along the vessel, setting the gas in motion towards the port. Fig. 1 shows the pressure inside the vessel at an instant when the wave has traversed about half the length of the vessel. In the portion on the left, in which the pressure is $p_0$, the gas is still at rest. On the right, where the pressure has fallen to $p_1$ by the passage of the wave, the gas is flowing towards the orifice with a velocity $v_1$, given by the relation expressed in equation (2), using the negative sign. The time represented by the sloping line from $p_0$ to $p_1$ is the time required for the port to open. The value of $p_1$ will be determined by the condition that the rate of arrival of gas at the port is equal to the maximum possible rate of discharge through the port for the prevailing conditions governing the discharge. The pressure $p_1$ remains constant so long as the gas continues to arrive at the port with constant velocity, that is, until the conditions at this end of the vessel are altered by the return of the pressure wave after reflection at the closed end of the vessel. When the wave has been reflected and has passed forward towards the port, the gas will again be at rest, and the pressure will have fallen from $p_1$ to $p_0^1$, corresponding to this change in velocity from $v_1$ to zero. Since this wave moves in the same direction as the gas, the final pressure $p_0^1$ is obtained from the equation for a forward wave, *i.e.*,

$$\left(\frac{p_1}{p_0^1}\right)^{\frac{\gamma-1}{2\gamma}} = 1 + \frac{\gamma-1}{2}\cdot\frac{v_1}{c_0^1},$$

here $c_0^1$ denotes the speed of sound at the final condition $p_0^1$. Fig. 2 indicates the pressure distribution inside the vessel during the return of the

*Fig. 1.*

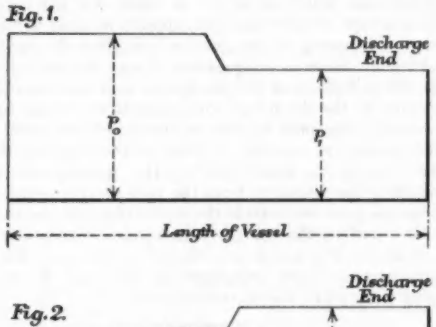



*Fig. 2.*

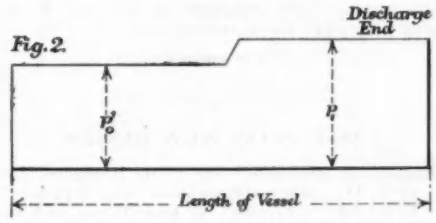
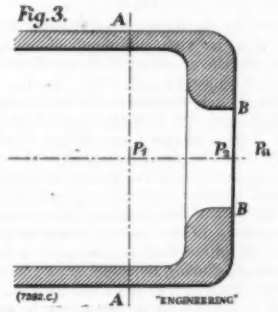



*Fig. 3.*




reflected pressure wave. When this forward wave arrives at the port, the forward velocity there would fall to zero and the pressure to $p_0^1$. In order to maintain the discharge, a second negative wave immediately leaves the port end of the vessel and the pressure at this end falls to a new value of $p_1$, corresponding to a new value of the forward velocity $v_1$ of the gas. Again, $p_1$ and $v_1$ are determined by the requirement that the rate of arrival of gas at the port should be sufficient to maintain the maximum possible rate of discharge through the port under the new conditions. This wave is reflected at the closed end and passes forward towards the port, leaving the gas again at rest and at a still lower pressure. This process is repeated throughout the period of discharge, so that the pressure inside the vessel decreases in steps, the time interval between two steps corresponding to the time required for the wave to make the double journey along the vessel. This time interval for the double journey is found from the expression for the speed of propagation of the wave. For the backward and forward movements through the vessel the speeds of propagation are $c_0 - \frac{\gamma+1}{2}\cdot v_1$ and $c_0^1 + \frac{\gamma+1}{2}\cdot v_1$, respectively. The mean speed for the total interval is therefore $\frac{1}{2}(c_0 + c_0^1)$.

It has been assumed so far that the time occupied by the opening of the port is short in relation to the time required for the wave to travel along the vessel, so that the pressure $p_1$ exists at the port during approximately the whole of the double period. The assumption of an almost instantaneous opening introduces no difficulty in the theory of the propagation of the wave, since it is propagated first in the negative direction. It is seen from the form of the expression for the speed of propagation of the wave that there will be a progressive change in the shape of the wave front as it moves either backwards or forwards. In the backward wave the speed of propagation varies from $c_0$, when the pressure is $p_0$ and the velocity zero, to $c_0 - \frac{\gamma+1}{2}\cdot v_1$, when the pressure is $p_1$ and the velocity $v_1$. The wave front therefore becomes less steep as the wave proceeds. After reflection the speed of propagation varies from $c_0^1 + \frac{\gamma+1}{2}\cdot v_1$ when the pressure is $p_1$, to $c_0^1$ when the pressure is $p_0^1$; the wave therefore becomes steeper again as it approaches the port, and arrives there with approximately the same form as that with which it left at the beginning of the interval.

The above considerations of the conditions during discharge are based on the assumption of a constant area of the discharge port. The same reasoning may be applied, however, to the more usual case in which the area of the port varies continuously during the discharge period. Any change in the area of the opening produces a negative wave, as already described, and this is superimposed upon the existing conditions in the vessel. Any known rate of opening of the port may therefore be divided into a number of time intervals, during each of which the port area is assumed to remain constant, but changes rapidly from one value to another between the intervals. The intensities of the pressure waves produced may then be calculated from a consideration of the flow through the port, and the effects of these pressure waves combined. If the intervals are chosen of short duration the result approaches the condition of a continuously varying port area, and a mean curve through the pressures thus calculated would give a good approximation to the actual pressure in the vessel. In applying this method to a practical problem it is convenient to choose each time interval as equal to the double period of the wave in the cylinder; the flow conditions then remain constant from the instant when the wave front leaves until it arrives back again at the port. An important point to be noted in connection with Figs. 1 and 2 is that the pressure at the closed end of the vessel may be greater or less than the pressure at the port, depending upon whether the wave is still approaching the closed end or is moving forward again after reflection. This has a very important bearing upon the conditions existing at the closed end of the vessel when the pressure at the open end has fallen to that of the atmosphere, and indicates that in certain circumstances a depression may exist inside the vessel. This will be considered in greater detail in the example worked out later in the article.

*Discharge Through the Port.*—At any instant, the gas inside the vessel is approaching the port with velocity $v_1$ and pressure $p_1$. Assume the cross-sectional areas of the vessel and of the port to be $a_1$ and $a_2$ respectively; $a_2$ being the effective area, when the coefficient of discharge of the orifice is taken into account. The pressure outside the port being $p_a$, that of the atmosphere, the pressure of the gas at exit may be greater than $p_a$, according to the magnitude of $p_1$ relative to $p_a$. This exit pressure may be denoted by $p_2$, and the exit velocity by $v_2$. In order to establish the discharge equation, it is convenient to consider two planes: A A within the vessel at the approach to the port, and B B at the exit from the port, Fig. 3. For unit mass of gas displaced at the plane A A, the work done by the gas behind it is $\frac{p_1}{\rho_1}$; similarly, the work done by unit mass at the plane B B is $\frac{p_2}{\rho_2}$. The net external work done by unit mass of gas is therefore $\frac{p_2}{\rho_2} - \frac{p_1}{\rho_1}$. The internal energies of unit mass of gas at planes

* Earnshaw, *Phil. Trans. Roy. Soc.*, vol. 150, page 133 (1860).

† Rayleigh, *Proc. Roy. Soc.* (A), vol. 84, page 247 (1910).

A A and B B are J $C_v T_1$ and J $C_v T_2$, respectively, J being the mechanical equivalent of heat, $C_v$ the specific heat at constant volume, and T the absolute temperature. The kinetic energies are $\frac{v_1^2}{2g}$ and $\frac{v_2^2}{2g}$ at the two planes. These quantities, when substituted in the equation representing the conservation of energy, give, for adiabatic conditions,

$$\frac{p_2}{\rho_2} - \frac{p_1}{\rho_1} + J C_v (T_2 - T_1) + \frac{1}{2g}(v_2^2 - v_1^2) = 0,$$

which reduces to the usual form

$$v_2^2 = v_1^2 + 2g \frac{\gamma}{\gamma - 1} \cdot \frac{p_1}{\rho_1} \left\{ 1 - \left( \frac{p_2}{p_1} \right)^{\frac{\gamma - 1}{\gamma}} \right\}. \quad (3)$$

It is well known that, for flow under these conditions, the mass flow through a discharge orifice reaches a maximum when the velocity at the minimum section of the jet reaches the speed of sound at the prevailing pressure and density. Further, if the initial velocity $v_1$ be zero, the pressure $p_2$ at this minimum section is related to the initial pressure $p_1$ by the equation

$$\left( \frac{p_2}{p_1} \right)^{\frac{\gamma - 1}{\gamma}} = \frac{2}{\gamma + 1}.$$

In the present problem the velocity $v_1$ is not negligible, and when this is taken into account it may readily be shown that the critical pressure ratio takes the form

$$\left( \frac{p_2}{p_1} \right)^{\frac{\gamma - 1}{\gamma}} = \frac{2}{\gamma + 1} + \frac{\gamma - 1}{\gamma + 1} \cdot \frac{v_1^2}{c_1^2}. \quad . \quad (4)$$

Here $c_1$ is the speed of sound in the gas at the initial condition, *i.e.*,

$$c_1 = \sqrt{\frac{g \gamma p_1}{\rho_1}}.$$

The exit velocity is then equal to the speed of sound at the exit conditions, or

$$v_2 = c_2 = \sqrt{\frac{g \gamma p_2}{\rho_2}}.$$

When the atmospheric pressure $p_a$ is less than the value of $p_2$ as given by equation (4), the rate of discharge is independent of $p_a$; the value of $p_2$ in equation (3) is then that derived from the critical pressure ratio, and the value of $v_2$ is the speed of sound. As $p_1$ decreases, the exit pressure $p_2$ also decreases, until it reaches that of the atmosphere. For lower values of $p_1$ the atmospheric pressure $p_a$ is substituted for $p_2$ in equation (3), and the exit velocity $v_2$ is then less than the speed of sound. It may be noted here that equation (3) is based on the assumption that the mass flow is the same at the planes A A and B B in Fig. 3. This is true when the pressures at these planes remain constant in time, as is the case during each of the intervals into which the total discharge period is divided. When the pressures vary, a small time interval is required for a disturbance at one plane to travel to the other, and if the planes are far apart, this time lag may have to be taken into account in deriving the equation for the final velocity. In the present problem the planes A A and B B may be chosen immediately before and after the discharge port, so close together, when compared with the length of the vessel, that the time for a change at one plane to reach the other is negligible. The mass flow may then be taken as the same at the two planes, and equation (3) is directly applicable to the discharge conditions, even when the pressure varies rapidly.

The initiation of the flow, at the instant when the port begins to open, requires some consideration, especially from the point of view of the resistance to flow offered by the gas outside the port. If the discharge were taking place into a pipe, the issuing gas would set up a pressure wave in the gas in the pipe. The gas flowing from the vessel might be considered to act as a piston, communicating its velocity to the gas in the end of the pipe; the accompanying variations of pressure in the pipe follow from equation (2), and the pressure wave is propagated along the pipe in the manner already described. The rate at which the gas begins to issue from the discharge port, and the manner in which the discharge increases, therefore, control the form of the wave produced in the pipe. In practice, however, the rate of discharge increases continuously from zero, since flow begins as soon as any finite area of discharge port is available, and in the problem considered the port area increases progressively from zero. Since any disturbance is transmitted through the gas with the speed of sound, the effect of any variation in the port area is communicated to the neighbouring gas with this speed; hence, unless the port opens with a speed greater than that of sound, variations in the area of the port will be instantaneously accompanied by variations in the rate of discharge. During the initiation of the flow, therefore, the pressure in the wave produced in the pipe increases continuously from zero. When the gas discharges into the atmosphere instead of into a pipe, a similar process takes place, but the pressure generated by the escaping gas is propagated outwards in all directions as a spherical wave. For a given rate of discharge, the increase in pressure in the spherical wave is very much less than in the plane wave produced in the pipe, and is, in fact, so small that its effect in resisting the discharge may be neglected. The important point, however, is that, for discharge into a pipe or into the atmosphere, so long as the rate of opening of the port is less than the speed of sound, there is no question of any discontinuity at the initiation of the discharge, and equation (3) applies to the discharge conditions from the instant at which the port begins to open. In the present discussion, no account is taken of the effect of the pressure wave generated in the atmosphere in resisting the discharge from the vessel; it is assumed that the pressure outside the vessel remains constant and equal to that of the atmosphere. As pointed out above, this resistance offered by the gas outside the port is more important in the case when a pipe is fitted to the discharge port.

*(To be continued.)*

## NOTES ON NEW BOOKS.

*Engineering Economics.* By T. H. Burnham, B.Sc. Book II: *Works Organisation and Management.* Fifth edition. London: Sir Isaac Fitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

The subject of engineering economics is set out by Mr. Burnham in two volumes, of which Book II relates only to the economics of manufacturing, except for a final reference to sales. In this, the 5th edition, are considered such matters as the functions of management, design, quality, and the control of progress and materials. The chapter on design is of particular importance; if the design is faulty, the work of the other departments will be largely wasted, and inefficiency must result. Special emphasis is laid on the economic aspects of design and on the value of a "cost-reduction sense" in the drawing office as an inspiration to produce simplified designs, to apply new and advantageous manufacturing methods, and generally to keep abreast of all improvements in materials and technique. The author's facility in presentation is well displayed in the chapter on the economics of production, in which he deals with the planning of production, rightly stressing that, although the amount of turnover expected is always the controlling factor in production, the manufacturer should not be hypnotised by mere volume; there is such a thing as "profitless prosperity," as many are now discovering by experience. The wise employment of jigs and fixtures is another matter intimately bound up with production costs, which the author considers in some detail.

*The Calculation and Design of Electrical Apparatus.* By W. Wilson, D.Sc., M.I.E.E. Second edition, revised. London: Chapman and Hall, Limited. [Price 10*s.* 6*d.* net.]

The comprehensive character of the title of this book would suggest a volume of considerable bulk, but Dr. Wilson has been able to deal with the subject in a very effective manner in 230 small pages, of which about a dozen are occupied with tables of logarithms and trigonometrical ratios. This has been possible because the physical principles and mathematical formulæ, with which the author is mainly concerned, are often applicable to a wide range of apparatus, the mechanical and detail design of which differs materially. The book, the first edition of which was issued in 1934, gives formulæ, data, and explanatory matter from which the design of static apparatus, such as switchgear, control gear, electromagnets, instruments, 'bus bars, insulators, windings, etc., can be worked out. For each quantity required, the author derives a formula generally from first principles, and then illustrates its application by means of a worked-out example from actual practice. In the first chapter, the relation between absolute and practical units is explained, and fundamental calculations relating to current, voltage power, etc., are given, subsequent chapters being devoted to heating effects, forces due to currents, resistors and rheostats, system short circuits, electromagnets, windings and solenoids, and heavy conductors, such as 'bus bars. The final chapter deals with the inductance and capacity of coils, dielectric constants, insulation breakdown, voltage gradients and corona effects. Throughout the book there are numerous diagrams and tables giving useful data in a convenient form, and each chapter is followed by a bibliography of works relating to the subject-matter of that chapter. In this, the second, edition, it is stated, the whole of the text has been revised and, where necessary, amplified. New sections have been added dealing with surges and other transient phenomena, liquid earthing resistors, the mathematics of the electric arc, and short-circuit test oscillograms; a reproduction of one of the latter now forms the frontispiece. The scale of this reproduction, we suggest, should have been made a little more obvious, and might well have been selected so that the measured ordinates have merely to be multiplied by a whole number. This, however, is a minor criticism of a work which fills an important gap in the extensive list of electrical text-books, and can be heartily recommended to all concerned with the mathematical design of electrical apparatus.

*Special Library Methods.* By John L. Thornton, A.L.A. London: Grafton and Company. [Price 10*s.* 6*d.* net.]

When reviewing an earlier book of Mr. Thornton's—*Cataloguing in Special Libraries*—in our issue of January 20, 1939, we suggested that it was not altogether clear what he understood by a special library; it appeared to be anything that would not usually be called a general library. In this new volume, his definition is specific. Special libraries are "libraries devoted to the use of special sections of the community"; that is to say, it is the clientele, not the contents, which determines whether a library is special or general. The matter is not of great interest outside library circles. An engineer would certainly call the library of the British Non-Ferrous Metals Research Association a special library, and will not greatly mind if the library of, say, King's College, London, is held to belong to the same class. The book is a description of methods followed in libraries of scientific societies and research organisations, universities, schools, etc. Mr. Thornton is the librarian of St. Bartholomew's Hospital Medical College, and not unnaturally pays considerable attention to medical libraries. The libraries of the great engineering institutions are not mentioned. Running through the book, and applied to every type of library dealt with, is the criticism that special libraries are too inclined to operate without trained librarians and consequently are usually either in confusion or, at least, do not make the best of their possibilities. Mr. Thornton does not overlook the fact that, for anyone to take useful charge of a highly-technical library, he must have some knowledge of the subject concerned. The author's attitude, however, is not quite consistent throughout the book. This is probably due to the wide definition with which he is working. In one place he says that "a technical knowledge of the subjects covered by the library can be acquired from contact with the literature." In another, that, "the appointment of experts with special qualifications as librarians is rarely possible . . . a trained librarian is preferable should it not be possible to combine the qualifications." In yet another place he says that "it is also advantageous to have a technical expert either on the library staff, or working in close connection with the library." It might be suggested that, if "a technical knowledge of the subjects covered . . . can be acquired from contact with the literature," then "a technical expert" should not be necessary. Clearly this matter is one of degree. In many of the types of library dealt with it is possible that a sufficient acquaintance with the subject or subjects concerned may be obtained by the librarian from contact with the material with which he is in charge. It is difficult to think, however, that the same thing would apply in the case of, say, a specialised chemical library. Obviously, the best procedure is that people with scientific attainments, who are interested in librarianship, should undergo proper library training. The difficulty appears to be that, in general, the financial prospects of library work are so unattractive that technically-trained people are not drawn to the field, and consequently do not deliberately take up librarianship as a career. As things are, it appears probable that the technical supervision necessary in research libraries will continue to be furnished by people who are not trained librarians.

# LETTERS TO THE EDITOR.

## FIFTY YEARS OF PRESSURE SCAVENGING.

TO THE EDITOR OF ENGINEERING.

SIR,—I feel greatly honoured by the close consideration which both Mr. E. S. Dean and Mr. T. D. Walshaw appear to have given to my article "Fifty Years of Pressure Scavenging," exemplified by their letters and charts reproduced in your issue of the 2nd inst. Despite their remarks, I refuse to be contrite for my use of the terms "British" and "Continental," applied to the competitive methods of pressure charging. We all agree that science knows no territorial boundaries, but, having in mind the Akroyd Stuart—Diesel controversy, I feel under no obligation to refrain from giving credit to a British engineer who merits it. But it was for another reason altogether that I deliberately chose to use the terms: I wished to avoid using trade names, for I was dealing with principles and not principals.

Mr. Dean seeks to convict me of loose thinking, but himself proceeds to counter my statement relative to cylinder pressures during the exhaust stroke by referring to oscillograph records of exhaust-manifold pressures! He quite rightly points out that, in the event of a breakdown of a turbo-charger, it would be possible for the engine to continue to operate if the turbine rotor is blocked to put it out of service—by that, he implies that a temporary stoppage only would be necessary. I had in mind, when writing my article, that a complete stoppage of the engine was necessary during repair and reconditioning, but now realise from his comments that I should have made that point more clearly.

To attempt to deal with the more controversial points made by your correspondents would lay me open to a charge of being a protagonist of a particular method of pressure-charging, which I certainly am not. I trust that other readers of my article will have appreciated the fact that it was written primarily for the purpose of emphasising that, even 50 years after Hamilton's original patent had been taken out, a modern system based on his original work was not deserving of the condemnatory allusions that have recently been made in pamphlets and brochures describing what, for my purpose, I still prefer to call the Continental system. I am grateful to Mr. Walshaw for agreeing with me, for after all his criticisms he reaches the same conclusion, stating clearly that: "In any given case either the mechanically-driven or the exhaust turbine-driven blower will have technical advantages over the other. The system to be used should be chosen on these technical merits, all other things being equal."

Another manufacturing firm than that with which Mr. Walshaw is connected appears to be of the same opinion, although it is not so clearly stated. In their descriptive pamphlet the following paragraph occurs:—

"Each method has its use. The mechanically driven blower method gives a considerably smaller increase in power and with a higher fuel consumption; but there are cases in which this method can be used with advantage, notably when it is desired to restore the sea level power to an engine running at altitudes up to 12,000 ft. We supply pressure chargers of this type, but only when a comparatively small increase in power is required."

When, after reading this statement, it is realised that the restoration of sea-level power to an engine working at an altitude of 12,000 ft. cannot be deemed "a comparatively small increase in power," the truth emerges.

Mr. Hunter's comments, in your issue of the 9th inst., upon exhaust-temperature readings brings a point of interest into greater prominence. The apparently increased temperature in a common main when compared with readings at cylinder outlets is, as he states, due to the natural conditions pertaining to each point. The number of impulses per unit time has always a marked effect upon differential exhaust-temperature readings at the two positions. It is observable, even when note is taken at one position only, for with high-speed engines working at equivalent outputs in terms of brake m.e.p.—the mixture strength of each impulse being similar—the lower speeds always show lower apparent exhaust-temperature readings when it is certain that the actual temperature at release is of the same order. In a pressure-charged engine, any increase in the volume of air admitted per impulse takes more heat from the internal surfaces and leaves less for the jacket water to abstract from the piston and walls and yet "cools" the exhaust; but I am of the opinion that, other things being equal, the exhaust-turbo charger shows a greater temperature difference than does the mechanically-driven charger. I am unaware whether any theoretical or practical investigation has been made and it would, as Mr. Hunter suggests, probably be worth while to have some research work carried out upon this. The published results of the Marine Oil Engine Trials Committee's sixth report (*Proc. Inst. Mech. E.*, 1931, page 242) confirm Mr. Hunter's figures as to a difference of 180 deg. F. under certain conditions with turbo pressure-charged engines.

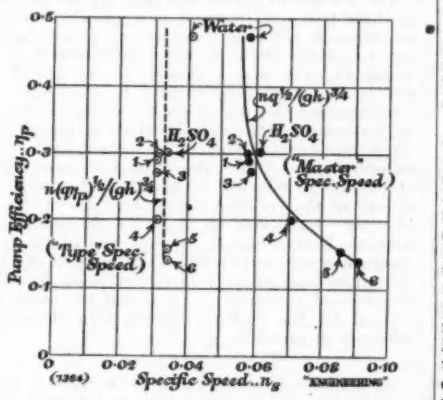
Yours faithfully,
W. A. TOOKEY.

83, Cumberland-road,
Bromley, Kent.
August 9, 1940.

## SPECIFIC SPEED OF PUMPS AND TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Towards the end of 1932, a well-known centrifugal pump builder* drew attention to the need for a dimensionless formula before Continental and British specific-speed figures could be reduced to a common basis for the comparison of individual "designs" or "types" of pump. The "master" formulæ, $n_s = \frac{n\,q^{\frac{1}{2}}}{(g\,h)^{\frac{3}{4}}}$ for pumps, and $n_s = \frac{n\,p^{\frac{1}{2}}}{\rho^{\frac{1}{2}}\,(g\,h)^{\frac{5}{4}}}$ for turbines, given by Mr. Jennings in his letter published in your issue of July 26, meet the need. They are interchangeable, and can be derived from dimensional considerations. The first can be used for turbines, and the second for pumps, if desired. They are




slightly simpler in form than the non-dimensional expression $n_s = \frac{n\,p^{\frac{1}{2}}}{(\rho\,g\,h)^{\frac{3}{4}}\,(2\,g\,h)^{\frac{1}{2}}}$ proposed in 1931† by Professor Wilhelm Spannhake for pumps and turbines. Mr. Jennings has referred to the influence of the efficiency of the pump upon the figure for specific speed obtained from the master and "local" formulæ for any particular design or type. A small pump dealing with a very viscous fluid will, for instance, have a higher specific speed than a large pump of the same "type," (*i.e.*, geometrically similar to the small pump) dealing with an inviscid fluid, because the efficiency of the former is lower than that of the latter.

The object of the present note is to show how master and local formulæ for specific speed can be altered so as to give figures of specific speed more truly indicative of "type." The change proposed by the writer consists of the introduction of the efficiency $\eta_p$ or $\eta_t$ of the pump or turbine into the master or local formulæ. The master expressions then become, $n_s = \frac{n\,(q\,\eta_p)^{\frac{1}{2}}}{(g\,h)^{\frac{3}{4}}}$ for pumps, and $n_s = \frac{n\,p^{\frac{1}{2}}}{(\rho\,\eta_t)^{\frac{1}{2}}\,(g\,h)^{\frac{5}{4}}}$ for turbines. Professor Spannhake's formula becomes, $n_s = \frac{(p\,\eta_p)^{\frac{1}{2}}}{(\rho\,g\,h)^{\frac{1}{2}}\,(2\,g\,h)^{\frac{1}{2}}}$ for pumps and $n_s = \frac{n\,p^{\frac{1}{2}}}{(\rho\,\eta_t\,g\,h)^{\frac{1}{2}}\,(2\,g\,h)^{\frac{1}{2}}}$ for turbines, and the local ones take the forms $N_s = \frac{N\,(Q\,\eta_p)^{\frac{1}{2}}}{H^{\frac{3}{4}}}$ for pumps and $N_s = \frac{N\,P^{\frac{1}{2}}}{\eta_t^{\frac{1}{2}}\,H^{\frac{5}{4}}}$ for turbines. The additional terms $\eta_p$ and $\eta_t$ are dimensionless and do not affect the non-dimensional nature of the amended master formulæ which could be described as "type" formulæ to distinguish them from the "master" expressions.

In order to illustrate the difference between master and type formulæ as defined above, the writer has roughly plotted the points shown in the accompanying graph. They are from the experiments made by Dr. H. Mawson* on a small centrifugal pump which pumped water, $H_2SO_4$, and oils Nos. 1 to 6 of increasing order of kinematic viscosity, and refer to a speed $n = 41{\cdot}67$ revolutions per second, with an optimum discharge factor $\frac{q}{n\,d^3} = 0{\cdot}03$. It will be seen that the master formula gives specific-speed figures ranging from 0·058 to 0·091, depending on the pump efficiency (which, of course, depends, in turn, on the kinematic viscosity of the fluid pumped), while the type formula yields an almost constant figure of 0·033, irrespective of the fluid pumped. In the writer's opinion, the type formula, by taking efficiency into account, is able to place with greater exactitude in its position in the scale of specific speed, any particular design or type of pump.

Yours faithfully,
G. G. MCDONALD, Ph.D., M.I.E.S.

Engineering Dept.,
The University, Glasgow, W.2.
August 5, 1940.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. F. C. Johansen, in his letter on page 96 of your issue of August 2, makes a suggestion presumably intended to simplify the representation of specific speed. This suggestion, however, completely changes its meaning and significance. By making specific speed a rate of rotation, and, therefore, of the dimension $\frac{1}{\text{time}}$, he arrives at the result $n_s = \frac{np}{w\,h\,q}$. For a turbine, $w\,h\,q$ is the input and $p$ the output, therefore, his expression for $n_s$ may be simplified still further to $n_s = \eta_t\,n$, where $\eta_t$ is the turbine efficiency. This meaning is entirely different from that which has always been recognised.

Despite Mr. Johansen's analogy with specific gravity and specific heat, specific speed cannot be regarded as a speed at all, but only as a dimensionless parameter similar to Reynolds number, or to the Peclet and Nusselt numbers in heat transmission. Just as Reynolds number is an indicator of the type of flow, so specific speed is an indicator of the type of machine. Its particular name is unfortunate, and is derived from the fact that its numerical value will be the same as the speed when each of the other terms is unity. Its physical dimensions cannot be the same as those of rotational speed. If the diameter of a pipe and the kinematic viscosity of the fluid were each unity, then the Reynolds number for the flow would be numerically equal to the speed of the fluid, but, fortunately, it was never called specific speed. I would suggest that a much better name would be "Pump or Turbine Type Number."

It may be of interest to note than $n_s$ is composed of powers of two simpler non-dimensional groups, viz.:—

$$n_s = \frac{n\,p^{\frac{1}{2}}}{\rho^{\frac{1}{2}}\,(g\,h)^{\frac{5}{4}}} = \left(\frac{p}{\rho\,n^3\,d^5}\right)^{\frac{1}{2}}\left(\frac{n^2\,d^2}{g\,h}\right)^{\frac{5}{4}}$$

or for pumps

$$n_s = \frac{n\,q^{\frac{1}{2}}}{(g\,h)^{\frac{3}{4}}} = \left(\frac{q}{n\,d^3}\right)^{\frac{1}{2}}\left(\frac{n^2\,d^2}{g\,h}\right)^{\frac{3}{4}}$$

where $d$ is the runner or impeller diameter.

It is known that a set of geometrically similar machines have almost exactly similar head-quantity characteristics. If they run at corresponding points on these curves, the values of $\frac{q}{n\,d^3}$ and $\frac{g\,h}{n^2\,d^2}$ are practically the same for all the machines. That they are not exactly the same is due to the fact that some of the losses are not quite proportional to the square of the speed. It follows, therefore, that for a set of geometrically similar machines running at similar points on the $h/q$ characteristic, the specific speed must be very nearly the same for each.

It is difficult to understand what is meant by Mr. Johansen's statement that "it is unfortunate that non-dimensional expression does not obviate changes of numerical value according to the system of units employed, even though the units of any one system are consistent among themselves." It is one of the important advantages of non-dimensional groups that if the units within the group are consistent, the numerical value obtained is the same whatever the system. True consistency means that each fundamental physical quantity involved can only have one unit throughout the group. Thus, if we choose one pound as the unit of mass, one foot as the unit of length, and one second as the unit of time, the unit of power must be one foot-poundal per second.

Yours faithfully,
J. JENNINGS.

Aston Technical College,
Birmingham, 6.
August 6, 1940.

* Mr. J. W. W. Drysdale, *Proc. Inst. Mech. E.*, December, 1932.

† *Kreiselrader als Pumpen und Turbinen*, J. Springer, Berlin, 1931.

* *Proc. Inst. Mech. E.*, vol. 2, pages 1035-1047 (1927).

## LABOUR NOTES.

Between June 17 and July 15 there was an increase of 60,431 in the number of unemployed persons on the registers of employment exchanges in Great Britain. The increase occurred among women, temporarily unemployed men, and juveniles; wholly unemployed men were fewer by over 46,000. The total of 827,266 for July 15 was 429,158 less than the figure for July 10, 1939. The increase since June 17 occurred mainly in coalmining, where there were temporary stoppages in a few areas, and in the textile, clothing, boot and shoe, leather and furniture industries. On the other hand there was a further reduction in the numbers unemployed in building and public-works contracting and in the distributive trades. Owing to the increasing extent to which persons actually in employment or likely to be soon in employment are now admitted to training centres, it has been decided to discontinue the practice of including, in the total of unemployed, the number of unemployed persons at training centres. If they had been so included this month the increase in the total of unemployed would have been 68,225.

Of the total number on the registers at July 15, viz., 827,266, 636,532 were wholly unemployed, 153,242 temporarily stopped, and 37,492 normally in casual employment. Of the wholly unemployed, 336,292 were men, 18,363 boys, 248,025 women, and 33,852 girls. Of the temporarily stopped, 76,958 were men, 2,765 boys, 69,293 women, and 4,226 girls, and of the casual workers, 35,716 were men, 103 boys, 1,665 women, and eight girls. Between June 17 and July 15, the numbers of unemployed increased by 26,260 in the London area, 1,770 in the Southern area, 2,254 in the Midlands, 4,097 in the North Midlands, 3,301 in the North-Western area, 9,180 in the Northern area, 3,218 in Scotland, and 12,731 in Wales. They decreased by 338 in the Eastern area, 1,088 in the Southern area, and 954 in the North-Eastern area.

In July, the home branch membership of the Amalgamated Engineering Union increased from 418,304 to 422,209, and the Colonial branch membership from 37,828 to 38,148. The number of members in receipt of sick benefit increased during the month from 3,686 to 3,887, and the number in receipt of superannuation benefit decreased from 13,636 to 13,527. The number on donation benefit increased from 447 to 457, and the total number of unemployed members decreased from 2,608 to 2,585.

It is stated in the August issue of the Amalgamated Engineering Union's *Journal* that following the refusal of the Admiralty to grant an increase of wages to certain sections of the membership, a case was submitted to the Industrial Court. The terms of reference were :—"That the base rate for fitters and turners, coppersmiths and blacksmiths in H.M. Dockyards and other Admiralty establishments at home, in which dockyard rates of pay are applied, be increased by the sum of 8*s.* per week of 47 hours." The Court, it is recorded, rejected the claim, but stated that their award was without prejudice to any claim which "may hereafter be made in regard to the rating of men as millwrights or tool makers or for a special rate for men when doing millwright or tool-making work." The executive council, it is added, are considering the question of pursuing the matter further.

It was mentioned some time ago in these columns that the workers' panel, from which representatives are to be selected to serve on the new National Arbitration Tribunal, is to be composed of Mr. W. J. Bowen, Mr. W. J. Farthing, Mr. Luke Fawcett, Mr. M. Hodgson, Mr. J. Kaylor, Mr. J. Stokes, Mr. A. M. Wall, and Miss Madeline Symons. The employers' panel is to consist of Mr. Clive Cookson, Lieut.-Colonel H. Rivers Fletcher, Mr. W. O. R. Holton, Mr. G. H. Parker, Mr. Herbert E. Parkes, Sir John R. Richmond, Sir Frederick J. West, and Mr. W. J. Wiggins. Mr. Justice Simonds, Sir John Forster and Sir Hector Hetherington have been appointed to the tribunal by the Minister of Labour and National Service. Mr. Justice Simonds is chairman.

In the course of a reference to the new Tribunal, the writer of the editorial notes in the August issue of the Amalgamated Engineering Union's *Journal* writes :—"We will frankly say that we regard this innovation with some misgivings. The proof of the pudding will be in the eating. It is laid down in the scheme that terms and conditions of employment are still to be settled, if possible, by the normal methods of collective bargaining each well-organised industry has evolved. Reference to the Tribunal of a dispute which proves intractable will be made only by one or the other of the organisations concerned—that is to say, a non-federated employer cannot carry his case to the Tribunal —and, as a general principle, the Tribunal must have regard to the recognised terms and conditions, and is not to make any award on less favourable terms. This may prove to be an important 'direction'."

Alluding to the transfer to the Ministry of Labour and National Service of the powers to administer the factory and welfare department of the Home Office, the writer says :—"If there is one need in war-time industry more clearly and forcibly emphasised it is that health and efficiency are two aspects of the same fact which require to be kept continuously in view. We consider it highly significant that Mr. Bevin took occasion recently to say that there was already evidence that the high rate of output secured in the 'spurt' the workers were called upon to make is not being maintained and that fatigue caused by overlong hours of work is the source of it. It has been proved beyond all argument that the effects of fatigue are cumulative. Patriotic incentives, to say nothing of other incentives of a more ponderable character, may help the workers to overcome the immediate effects of fatigue and keep going for some time. But as was pointed out by the leading expert on this subject in the last war (Professor H. M. Vernon), the output of munitions must be maintained and expanded over a period of months and probably years, and it is foolish and dangerous to overstrain the most willing of the workers in the early stages of war production. That spells a serious loss of efficiency and, therefore, of output in the later stages."

The Minister of Labour and National Service issued an Order last week requiring men not wholly engaged on war work in certain occupations—mainly engineering—to register at the nearest Employment Exchange during the five days beginning on August 19. All men in the occupations covered by the Order must register unless they are at present employed full time on Government work or employed in the iron and steel, non-ferrous metal manufacture, shipbuilding or railway industries. The Order also applies to men between 21 and 65 who have had not less than 12 months' work in any of the specified occupations during the last 12 years. Employers are to play a part in the registration. Every employer of any men in the named occupations is to make a return by August 28 of all men not wholly engaged on Government work for all the five days of registration. A list of the occupations covered by the Order is included in the editorial reference on page 133.

At a recent meeting, Birmingham Trades' Council passed, with two dissentients, a resolution expressing the opinion that the time has arrived when serious consideration should be given to the question of compulsory membership of appropriate trade unions in all sections of industry where agreements covering wages and conditions have been negotiated by the unions concerned. The resolution was moved by Mr. J. J. Grogan, National Association of Operative Plasterers. He said the principle of compulsory service, both military and industrial, had been accepted. The voluntary principle no longer sufficed.

Australian and New Zealand Association for the Advancement of Science.—The meeting of the Australian and New Zealand Association for the Advancement of Science, which should have been held this month at Adelaide, has been postponed.

Motor-Car Manufacture in Canada.—According to a recent issue of *Canadian Machinery*, final statistics for 1939 show that the total production of motor cars in the Dominion was 155,426, as compared with 166,086 in the previous year, representing a decrease of 6·4 per cent. It should be noted, however, that while passenger cars declined from 123,761 in 1938 to 108,369 in 1939, commercial vehicles increased from 42,325 in 1938 to 47,057 last year.

Bibliography of Steel Sheet and Strip.—The Sheffield City Libraries have issued a further research bulletin in their series dealing with sheet and strip. This, which is designated No. 4, consists of a bibliography of sheet and strip finishing processes and of special sheet materials, and all the books and periodicals referred to may be consulted in the Science and Technology Department of the Sheffield Central Library, which is open from 9.0 a.m. to 9 p.m., on week-days. Copies of this bulletin and of bulletin No. 3, which dealt with the production of sheet from slabs and of slabs from ingots, may be obtained, either singly or together, on the receipt of 3*d.* for postage, from the City Librarian, Central Library, Surrey-street, Sheffield, 1.

## INSTRUMENT FOR MAGNETIC DETERMINATION OF CARBON IN STEEL-BATH SAMPLES.

During the last 20 years of the Nineteenth Century various instruments were developed for determining accurately the magnetic properties of steels employed in transformers and other electrical machines, and some few investigations were made to ascertain what relationship existed between the magnetic properties of a steel and its carbon content. In this connection, in two papers, both published in the *Proceedings* of the Institution of Civil Engineers in 1896, Ewing described the equipment necessary for the determination of the permeability of steel specimens and H. F. Parshall furnished data on the flux densities, at various magnetising forces, for steels containing from 0·17 per cent. to 0·70 per cent. of carbon. A little later, in 1898, Madame Curie, in a contribution presented to the Société d'Encouragement pour l'Industrie Nationale, established definitely that the magnetic flux though a hardened-steel specimen was related to the carbon content at a fixed magnetising force. The matter appears to have remained of purely academic interest

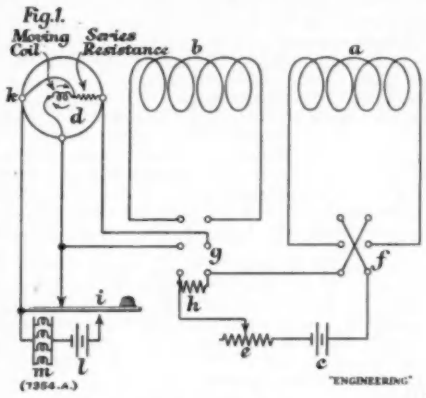



Fig.1.

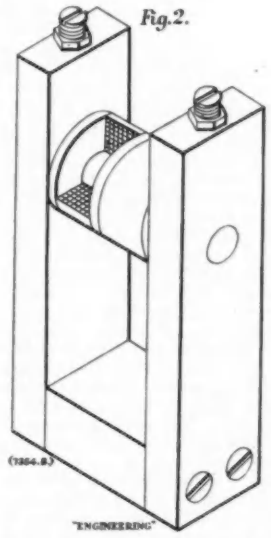



Fig.2.

for a long period, but some ten or twelve years ago Malmberg, the Swedish scientist, introduced his Carbometer, in which the principle of change in magnetic properties with change in carbon content is employed for the rapid determination of carbon in steel. Other instruments, somewhat similar in principle, have been developed in recent years, the latest being an apparatus called the Carbanalyzer, which has been brought to our notice by Messrs. Griffin and Tatlock, Limited, Kemble-street, Kingsway, London, W.C.2, who are the agents in this country for the makers, the Fisher Scientific Company, Pittsburgh, Pennsylvania, U.S.A. We are informed that several of these instruments are now in use in this country, and are understood to be giving very satisfactory results.

The instrument was originally developed to facilitate the working of a small open-hearth furnace in the research and development laboratory of the Jones and Laughlin Steel Corporation, Pittsburgh. Further tests, however, were carried out on a larger scale in the open-hearth melting shops of the firm, and these proved so satisfactory that arrangements were made with the Fisher Scientific Company to make the instrument generally available to the steelmaking industry, more particularly for the determination of

carbon in furnace-bath samples. The Carbanalyzer, in its final form, was described in a paper presented recently before the American Institute of Mining and Metallurgical Engineers by Messrs. H. K. Work and H. T. Clerk, the former of whom is manager, and the latter physicist in the research and development department of the Jones and Laughlin Steel Corporation. The Carbanalyzer, it is explained in this paper, may be considered as a special form of permeater, since it measures the change in flux in a steel bar specimen produced by a known change in magnetising force. The bar specimen is made the core of a small transformer and the induced current, which varies with the carbon content, is then measured. The percentage of carbon is read off from a calibration curve. The electrical circuit of the instrument is shown diagrammatically in Fig. 1, on the opposite page. The coils *a* and *b* constitute the primary and secondary windings of a special induction coil. The current flowing through the primary coil is supplied by a battery *c*, is measured by a millivoltmeter *d*, and is controlled by the rheostat *e*. It is reversed by the switch *f* and a second double-pole, double-throw switch *g* is inserted in order that the same millivoltmeter may be used in both the primary circuit (in parallel with the resistance *h*) to measure the steady current, and in the secondary circuit to act as a ballistic instrument. The arrangement of the millivoltmeter is such that it may be short-circuited when not in use to prevent damage to the moving parts. Furthermore, the meter is short-circuited to protect it during the several reversals of current necessary to put the specimen into a standard condition. The push-button switch *i*, when in the normal position, short-circuits the meter through the terminal *k*. When pushed down for a reading, the switch releases the millivoltmeter, and lights up, by means of the battery *l*, the group of flash-light bulbs *m*, which are arranged above the scale on the meter.

The magnetic unit of the apparatus is shown in Fig. 2, opposite. The primary and secondary coils are wound on a hollow Bakelite form and are held in position between the two heavy soft-steel plates seen in Fig. 2, and forming the sides of the yoke. The cylindrical bar specimen of steel under examination is thrust through the holes in the yoke and coils, and is held in good magnetic contact with the yoke. It is emphasised that the specimen may be inserted and withdrawn readily and will always be held in the same position and with the same side thrust against the yoke. Repeated tests on the same specimen, it is stated, have demonstrated that the readings are reproducible, indicating that the same magnetic coupling is secured each time that the specimen is inserted. The whole arrangement constitutes a closed magnetic circuit and stray magnetic fields in the vicinity of the apparatus cause no trouble. The Carbanalyzer is arranged in a rectangular box or cabinet measuring 10 in. by 10 in. by 14 in., and weighing 30 lb. The batteries are placed in a special compartment in the base, so that the unit is completely self-contained and portable.

The main feature of the instrument is the rapidity with which results are secured, it being claimed that a report of the carbon figure is obtained five minutes after pouring the molten sample. In making a test, the furnace melter takes a bath sample in the ordinary way, "kills" the steel with a measured quantity of aluminium wire, and pours it into a funnel-headed cylindrical split mould. If the carbon content is known to be between 0·05 per cent. and 0·40 per cent., the metal is left in the mould for a standard period of one minute and then quenched in water. If the carbon content is known to be within the range 0·35 per cent. to 1·5 per cent., the sample is quenched in water immediately the metal has set. This procedure, it may be added, has been standardised as the result of numerous tests. After quenching, the sample is dried and is ready for insertion in the socket provided for it in the apparatus. The accuracy of the results obtained is indicated by a table given in the paper by Messrs. Work and Clark. This shows the figures obtained by the Carbanalyzer and by the combustion method on 112 samples of steel ranging from 0·10 per cent. to 1·07 per cent. carbon; 94 of the 112 results given by the Carbanalyzer are within ±0·02 per cent. carbon of the value yielded by the analytical method. In most of the remaining cases the accuracy is within ±0·03 per cent.

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REPAIR WORKSHOP FOR THORNYCROFT MARINE ENGINES.—Messrs. John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, inform us that on account of the necessity of concentrating on the production of engines and other machinery at their marine-engine works, special arrangements have been made for conducting the overhaul and repair of marine engines at a fully-equipped repair shop on the South Coast. Further information can be obtained on application to the firm at the address given above.

## THE FUTURE OF BRITISH CIVIL AVIATION.*

(*Continued from page* 107.)

THERE is always a possibility of structural failure. In recent years this has largely been confined to retractable undercarriages, but there have been enough failures of other kinds to indicate that we have no cause for complacency. The dangers are: (*a*) straining after reduction in dead weight; (*b*) ignorance of the characteristics of new forms of structure and material; and (*c*) ignorance of the applied loads. In the case of (*a*), the remedy lies in the continued refinement of methods of calculation and test. As an example, it is at present common practice to assume that the applied loads are unaffected by distortion of the structure to which they are applied. In fact, however, the twisting of a wing under the aerodynamic loads corresponding to some chosen acceleration is sufficient to modify the distribution of the loads, and the correct system is the one which is consistent with the deformation it produces. This effect is commonly ignored, and there is little doubt that in future it will have to be taken into account.

The second danger, (*b*), in a responsible industry, is not great. Intensive research has been conducted on plastic materials, and it is unlikely that any such material will be used for primary strength in a civil aeroplane until certain weaknesses have been deleted. The best example of a new method of construction is the geodetic system. This was the subject of intensive research before it was employed. Ignorance of applied loads, (*c*), is probably the greatest danger from the structural point of view. The applied loads are of two kinds—those induced by manipulation of the controls and those consequent upon the weather. The usual procedure is to design to meet the worst accelerations of either kind which are likely. In the case of an aerobatic civil aeroplane, the greatest acceleration is likely to be little more than that at which the pilot blacks out. This is a variable quantity depending on the pilot and his posture, but is of the order of 6 *g*. Some reserve of strength on this figure is required and the present "aerobatic C.P. forward factor" of 9 does not suggest too great a margin. In the case of an air liner, violent accelerations of this kind are not permissible nor necessary. The only serious accelerations likely to be induced deliberately by the pilot are in avoiding collision, a circumstance which must be precluded by organisation rather than allowed for in design. The conditions we use for designing to withstand gust actions are to some extent arbitrary. On all routes the velocity-acceleration recorder should be carried in order to obtain the greatest mass of data in the shortest possible time.

The next great problem of inherent safety is ice accretion. Ice affects aeroplanes in at least seven ways. It interferes with carburation and so causes engine failure. It adheres to airscrews and causes lack of balance, which can wreck airscrews and engines. It sticks to wings and destroys their aerodynamic qualities. It gets into the hinge gaps of control surfaces, causing them to jam. It forms on struts and aerials and can, in consequence, produce structural failure. It forms on windows and obscures the pilot's view. It forms on Pitot heads, interfering with air-speed indicators. It is safe to say that problems of engine and instrument icing are solved, and all that is now needed is a strong policy insisting on the incorporation of the safety measures in all except acknowledged fair-weather aircraft. We are learning how to deal with hinge gaps and window problems. The slinger ring method of airscrew de-icing has been fairly successful, but does not always work. This is a problem for intensive research. The problem of ice formation on wings cannot be regarded as solved. Assuming that it is necessary to prevent the formation of ice on wings, the goal is a method which is 100 per cent. effective and does not interfere with the aerodynamics of the wing. The best device to date cannot claim 100 per cent. efficiency, and by gross deformation of the wing leading edge profile is aerodynamically damaging. Other methods are in varying stages of development, but the use of heat is the only one effectively free from aerodynamic disadvantages. This method has received little attention here, but if we must de-ice wings we must put a lot of energy into developing it. I think most of us feel that wing de-icing is necessary, but we must make quite sure before much more time and money are spent on developing de-icing devices. The early accidents seem to have been due to ice building on the leading edges of wings, which were "thin" in the absolute sense of the word and in the sense that the thickness/chord ratio was small, in such a way that the shape ruined the airflow. On the leading edge of wings that were "thick" in the absolute sense and in the sense that the thickness/chord ratio was large, the ice seems always to have built up in a neat form. It is possible that wing sections could be chosen for which ice accretion was not dangerous, and which consequently required no de-icing devices. In my view, this is a matter to be dealt with at the beginning of the civil research programme.

Fire in the air is fortunately rare, but its prevention is still one of our serious problems. More common is the danger of fire after crashing; this risk diminishes with improved reliability in flight. Fire in the air may arise from engine failure, passenger carelessness, and fuel jettisoning. Engine fires can be combated by fire-fighting equipment in the engine compartment. Passenger carelessness can be combated by the use of fireproof furnishings and strict control. Danger from fuel jettisoning, resorted to only when danger of some other kind is present, is prevented by correct design. In the case of engine fires, the root trouble may be vibration, which fractures a pipeline. The elimination of vibration, the development of vibration-resisting and fire-resisting pipelines and the discovery of fuel with high flash points are all important parts of fire prevention. Safety fuels have been developed. They cannot be used with ordinary carburettors, but could be directly injected. This is a sufficient argument for the intensive development of the direct-injection engine.

The steps taken to ensure the inherent safety of an aircraft do not guarantee safety in operation. Maintenance is in the hands of ground engineers, who are supervised by the surveyors of the Air Registration Board. They are not allowed to practice without a licence obtained through an examination. Before a passenger-carrying aircraft can begin a day's flying, ground engineers have to certify that it is fit to fly. With the development of metal construction and the increasing size and complication of a modern aeroplane, the knowledge and experience required of a ground engineer has increased correspondingly. Before the war, it was apparent that more searching examinations had become necessary, and the Air Registration Board had begun to examine the problem of elevating the standard. They will have to examine the possibility of licences of different standards. A man who certifies an Empire boat is obviously required to have knowledge and experience on a different scale from one whose responsibilities are limited to a Moth. A useful analogy is the gradation of licences (tickets) issued by the Board of Trade to marine engineers.

*Design and Construction.*—The design of an aeroplane is a compromise between the four qualities of safety, convenience, economy and prestige. Our future success will depend in large measure on our technical initiative. Too often we seem to have had ideas and forgotten them until after others have developed them. In the histories of flaps, metal construction, and retractable undercarriages, we made a creditable early appearance, but we only used these devices when their value had been proved elsewhere. Most probably our hesitation has been due to the absence of a progressive civil policy. A declared programme including, say, the institution of fast non-stop daily passenger services to North America and a daily departure for Australia, and requiring the development of types specially designed for the internal lines of Britain, Australia, Canada, India, and Africa, providing opportunities for the development of promising ideas, would be an inspiration to civil design. Without some such policy our civil design will become pedestrian. Some of the big jumps of the future—pressure cabins, laminar boundary layers, pusher airscrews, Diesel and direct-injection engines, and all-wing aircraft, could have profound effects on design and we should be estimating, designing, building and testing to assess them.

In the modern air liner of to-day, the slipstream from the airscrews, by increasing the air speed over the wings, enhances the lift and so improves the take-off or, alternatively, permits higher loading. The same slipstream, however, encourages turbulence in the air flow over the wings, and so reduces the extent of the low drag laminar flow area. With the possibility of developing wings with the transition to turbulent flow much farther aft than formerly, the disadvantages of the disturbing effect of the slipstream may well outweigh the effect of increasing lift. It would be instructive, therefore, to design an aeroplane to take maximum advantage of the pusher airscrew. In such an aeroplane it would be necessary to ensure that the cooling air for the engines entered and left without disturbing the laminar flow over the wings. Because of the need for keeping the centre of gravity of the aeroplane at the centre of lift, it might not be possible to change the positions of the engines appreciably. This would mean shaft drives to the airscrews—a retrogressive step from the weight point of view. The restrictions imposed by the centre of gravity consideration have urged the engines forward from the wing leading edge. When the nacelles carry airscrews ahead of them the result, probably because we have

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* Summary of the Wilbur Wright Memorial Lecture of the Royal Aeronautical Society, delivered on May 30 by Dr. H. Roxbee Cox.

become used to it, looks right enough. When the airscrews are displaced to the rear, however, the projecting engines have a purposeless appearance. If the aeroplane is large, it is probable that the centre of gravity difficulty can be overcome to allow the engines to be submerged in the wings. Another possibility is to arrange the four engines in two nacelles i.e., with two pairs of tandem airscrews. With this arrangement, with which a solution to the centre of gravity problem is possible, a little lift from the slip-stream is available, and the drag increase due to turbulence is less than it is with four tractor screws. Moreover, the two pairs of tandem airscrews may have a higher efficiency than the four single airscrews, and on the balance this arrangement may possibly be superior to the others. The three arrangements should be compared. Three designs would have to be made, all with the same power plant, useful load and range. If the estimated speed of either of the less conventional schemes was appreciably superior to that of the current arrangement, there would be a case for constructing an experimental prototype to check the design under operational conditions.

Other schemes which could with advantage be considered in detail arise from the consideration of the design of large aeroplanes. In the article on "Large Aeroplanes" in the *Journal of the Royal Aeronautical Society* for July, 1938, I discussed the problem of the large aeroplane and explained the necessity for spreading the masses across the span and of distributing the landing and take-off reactions in order to neutralise the tendency of structural weight to increase uneconomically with increase of size. This led to the idea that very large aeroplanes will be all-wing aeroplanes. Now, while the all-wing arrangement is highly efficient structurally, it is efficient as a load container only in very large sizes. This is because the ratio of surface to volume for a wing is large in comparison with that ratio for a fuselage and because head room is restricted. Consider the case of a 20,000-lb. aeroplane. For a wing loading of 30 lb. per square foot, its total surface area would be about 3,000 sq. ft. Its fuselage would have plenty of head room and its wings, nowhere more than 3 ft. thick, would carry nothing but engines and petrol. To make an all-wing aeroplane of the same all-up weight, the maximum wing depth would have to be about 8 ft. instead of 3 ft. and even allowing for a wing section half as thick again, its superficial area would be about 10,000 sq. ft. When in the natural course of things, however, the wing has reached a size capable of containing passengers, it is clearly wasteful not to make some reduction in fuselage size; and when, as in very large sizes, the wing is able to contain the useful load, a fuselage is clearly an unnecessary appendage.

These considerations suggest that, as we make aeroplanes larger and larger, we may expect a transition from the characteristic construction of wing and fuselage towards the all-wing arrangement. In that the argument ignores the effect of form and improvement in structural materials on structural weight, it is inaccurate; but in that the transition permits the spanwise spreading of load, it is consistent with the maintenance of structural efficiency. Even on the basis of constant distribution of mass in a wing-fuselage arrangement, the fuselage tends to diminish relatively to the wing for constant wing loading and constant percentage pay load. This is because the fuselage volume is then required to increase proportionately with the wing area, and while wing area varies as the square of the linear dimensions, the fuselage area varies only as the 3/2 power. With the help of Mr. W. Tye, I have made a quantitative examination of the question of load stowage in the design of large aeroplanes. The result shows that, taking 50 lb. per square foot as a wing loading likely to be realised in practice soon, for small aeroplanes there is no room for passengers in the wing. At 100,000 lb. the wing begins to have a little accommodation in it, and for a 15 per cent. stowed load at 280,000 lb., the wing can accommodate as much as the fuselage. At 380,000 lb., there is no need for a fuselage. This emphasises that true all-wing aeroplanes will be big. It is interesting to realise that had the means of increasing wing loading been delayed for a few years, we might by now have seen the all-wing aeroplane in being. The first steps were in fact taken in a notable German aeroplane, the Junkers G. 38, designed by Dr. Junkers, who took out a patent for an all-wing aeroplane in 1907. This machine had a wing loading of 16 lb. per square foot and a stowed load of about 13 per cent. of the all-up weight.

*(To be continued.)*

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Shipbuilding in the United States.—According to figures issued by the American Bureau of Shipping, there were under construction in the shipyards of the United States, at the beginning of July, 291 vessels, aggregating 1,567,000 gross tons. These totals, it is pointed out, are more than double those for July, 1939.

## "ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

*The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.*
*Where inventions are communicated from abroad, the names, etc., of the communicators are given in italics.*
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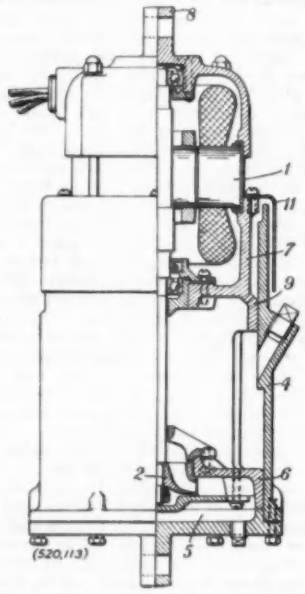
*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*
*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

### HYDRAULIC APPARATUS.

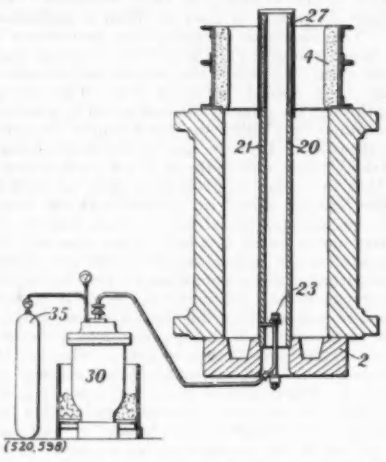
**520,113. Small "Thrustor" Unit. The British Thomson-Houston Company, Limited, of London, and A. T. Stretton, of Rugby.** (1 *Fig.*) October 27, 1938.—The invention is a modification of the company's "Thrustor" unit which enables it to be manufactured economically in small sizes by reduction of the number of parts required, a portion of the motor casing being utilised as the piston. A vertical electric motor 1 has an impeller 2 secured to the end of its shaft. This impeller forces oil from the cylinder 4 into a chamber 5 on the underside of a piston 6. The piston is integral




with the lower part of the motor housing 7, so that the upward force on it is transmitted to the upper part carrying the connecting lug 8. A cylindrical surface 9 on the motor casing slides in the upper portion of cylinder 4. The upper and lower portions of the motor casing are bolted together and a cover 11 prevents the entrance of grit between the cylinder wall and the motor casing. When the current is switched off, the piston and motor fall by their own weight, the oil being passed back to the interior of the cylinder from the pressure chamber. Spring-loaded baffle plates can be arranged at the inlet of the impeller to give retarded upward or downward strokes where these are required. (*Accepted April* 15, 1940.)

### METALLURGY.

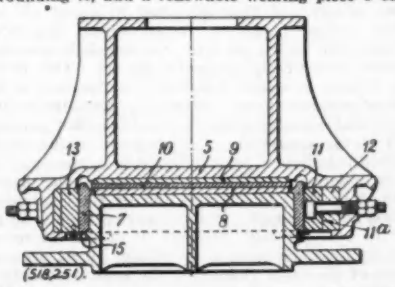
**520,598. Ingot Mould. Metropolitan-Vickers Electrical Company, Limited, of London, English Steel Corporation, Limited, of Sheffield, and R. W. Bailey, of Hale.** (4 *Figs.*) October 26, 1938.—The mould is primarily intended for the production of hollow steel ingots, and is designed to give castings in which the amount of segregation that occurs in the region of the core of the mould is reduced by increasing the amount of molten metal frozen around the core. The body of the ingot mould is mounted on a base 2 and supports a refractory head 4. The core comprises a hollow pillar 20, which registers at its lower end with an opening in the base 2, and a thin metal shell 21, which surrounds the pillar and forms the outer surface of the core. The pillar is held in place by a bolt threaded into a cross-bar 23, which engages projecting ledges on the inside of the pillar. The upper part of the shell 21 within the head 4 is surrounded by a metal sleeve 27, which constitutes the inner surface of the head of the ingot. To reduce cooling of this head, the upper part of the pillar 20 is reduced in diameter and the space within the shell 21 at this part is filled with a heat-insulating material. The shell has sufficient thermal capacity to freeze quickly a layer of metal surrounding it, but is itself heated nearly to the temperature of the freezing layer, so as to become plastic and offer little or no resistance to compression by the ingot. It is thus able to contract with the ingot as the latter cools. The shell may be fluted parallel to its axis so as to increase its flexibility. The heat is transferred to the pillar for extraction by a solid cast-iron, steel, or copper bar suspended within the pillar. The gap between the shell and the pillar contains a low melting-point metal, such as lead, which improves the thermal conductivity between them and counterbalances the force on the




shell 21 due to the hydrostatic pressure of molten metal in the ingot. The lead is run in during the pouring of the ingot and the height of lead within the shell is controlled to counterbalance the pressure of the metal on the shell and to regulate the heat flow from the ingot so that the lower part is cooled more rapidly than the upper part. The heated outlet pipe of an airtight melting pot 30 in a furnace leads to the bottom of the pillar, and is connected to an orifice in the wall of the pillar. For heating the pipe, the secondary winding of a transformer is connected between the pot 30 and pillar 20. The pot 30 is also connected to a compressed-air cylinder 35 through a regulator valve, by which the pressure in the pot is raised to force the molten lead up the annular space between the shell 21 and core 20. The height of lead within the shell is estimated from the pressure of air within the pot. (*Accepted April* 29, 1940.)

### RAILWAYS AND TRAMWAYS.

**518,251. Pivot for Articulated Locomotive. Beyer, Peacock and Company, Limited, of Manchester, and S. Jackson, of Stockport.** (4 *Figs.*) December 1, 1938.—The invention is a pivot centre for articulated locomotives, and is designed to prevent the ingress of coal dust and grit and the resultant rapid wear of the spigot and socket pivot centres. Hitherto, the socket centre has been placed beneath the spigot centre, leaving the open edges of the vertical bearing surfaces directed upwards. Grit thus lodges on them and works down between them. The socket pivot centre 5 is arranged above the spigot centre. The latter has a renewable wearing ring 7 surrounding it, and a renewable wearing piece 8 on its




upper surface. The socket pivot centre 5 has a similar wearing piece 9 on its lower surface and loose wearing blocks constitute the vertical surface. One form of block 11 is adjusted by moving a wedge 12 along the tapered surface 11*a* of the block. A different form of wearing block 13 is adjusted by shims inserted behind it. The vertical working and wearing surfaces of the assembly are therefore entirely renewable. An annular plate 15 provides additional protection for the vertical working surfaces of the centres and retains lubricant. Owing to the arrangement of the socket above the spigot ingress of grit to the vertical and horizontal wearing surfaces is avoided. (*Accepted February* 21, 1940.)

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